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DISEASE GERMS.

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DISEASE GERMS;

THEIR

NATURE AND ORIGIN.

BY

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SECOND EDITION.

TWENTY-EIGHT PLATES CONTAINING MANY COLOURED ILLUSTRATIONS.

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PREFACE

TO THE SECOND EDITION.

THE views concerning the nature and origin of disease germs, now published for the first time in a connected form, were briefly sketched in the lectures I delivered at Oxford in 1868–9 by direction of the Radcliffe Trustees, and have been taught by me in my lectures at King's College for many years past. The conclusions arrived at have resulted from careful microscopic investigation of the tissues and fluids of the body carried out by the aid of the highest magnifying powers yet made. Some of the facts will be found recorded in my Report on the Cattle Plague in 1866, and in memoirs and works published as early as 1863.

The treatment of febrile diseases discussed in the latter part of this volume formed the subject of

lectures delivered at King's College Hospital. These were published in the Medical Times and Gazette in 1871–72.

The illustrations in the present volume are, I think, in advance of any yet published by me. By printing in three colours, very accurate copies of the specimens prepared by the process of investigation I have long adopted have been obtained. Although far less beautiful than the preparations themselves, the figures in the last few plates of this book really record with accuracy the appearances observed.

The method of preparing the specimens for examination under the highest magnifying powers is the same that I have employed for many years past. This has been described in detail in other works.

From careful investigations, extending over many years, I have been led to conclude that the particles concerned in the propagation of contagious diseases are allied in constitution to the living matter or bioplasm of the organism. The matter of which disease germs consist is not, therefore, a non-living gaseous liquid or solid substance, but the disease exciting material is in an actually living state. I do not think it is derived from fungi or other low vegetable

organisms, and I have adduced facts and arguments in this work which I think justify the inference that neither "microzymes," nor "bacteria," nor "fungi," nor any of the lower forms of life are concerned in the production or in the propagation of the contagious fevers of animals and man.

It seems to me probable that the subtle poison originated and multiplied in man's own body, or in the bodies of some of the animals domesticated by man. I consider that it has been derived by uninterrupted descent from the bioplasm or living matter of an organism which at an antecedent period may have been perfectly healthy.

Man therefore can alone be held responsible for the development of these disastrously potent particles; and I believe that if our predecessors had been accurately acquainted with all the circumstances favourable to the production and propagation of disease germs, and had submitted to be guided by the laws of health that might have been deduced from such knowledge, we should now be living, even under the adverse conditions imposed upon us by modern civilization, without the risk of being decimated by pestilent scourges. Such happiness, however, cannot be the

lot of this generation, nor, I fear, of that which is immediately to succeed ; but it is perhaps conceivable that it may be enjoyed by those brought up under the improved sanitary conditions that will be established in England, let us hope, at no very distant period.

April 26th, 1872,

61, *Grosvenor Street.*

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PART I.

DISEASE GERMS:

THEIR

SUPPOSED NATURE.

POISONOUS matter exists in different states. There are poisonous solids, poisonous liquids, and poisonous gases. These kill man and the higher animals in many different ways. Some destroy the textures of the body; others interfere with the due discharge of function on the part of certain tissues and organs, the proper action of which may be necessary to the living state; while others again actually kill the living matter of the body; and of these there are poisons which act as soon as they pass into the organism, almost instantaneously,—and poisons which produce their deleterious effect very slowly. There are again substances which act as poisons to *every known kind of living matter*, while certain principles of vegetable origin which destroy some vertebrate animals with unerring certainty may be eaten freely by others, and even constitute their ordinary food.

Of all the poisons which cause the death of man, the most subtle and the most difficult to isolate and

investigate are those which give rise to certain forms of disease which spread from person to person. Many poisons of this class, as compared with non-living poisonous agents, act very slowly, and when they destroy life, do so, not by their immediate action upon tissue or living matter, but by their indirect influence upon the physiological changes going on in various tissues and organs. Many of these poisons are indeed uncertain in their action, and are for the most part fatal to a very small percentage of those attacked. They not unfrequently cause serious structural damage in consequence of which the organism becomes predisposed to certain forms of disease; and oftentimes, although the individual invaded escapes with his life, some delicate organ is irreparably injured by the changes produced by the action of the poisonous material, and death follows after a varying interval of time, but long before the ordinary period of life has been reached.

These poisons not only seriously derange the healthy functions, but having entered the body they multiply many million fold. They are *living*, and increase as living particles alone increase. They grow, they feed upon the nutrient juices of the organism and upon the tissues, and in some cases flourish at their expense and destroy them. The poison when it enters may be so infinitesimal in quantity, that it can neither be measured nor weighed, nor under ordinary circumstances seen ; but having gained access

to the blood and tissues, it increases to such an extent that in many cases sufficient is produced in one subject to infect hundreds of persons, the population of a town, or even a whole country.

The infecting matter has been supposed by some to consist of some subtle entity, which was not cognizable by the senses, or to be made evident in any way. By others it has been considered to be matter in a gaseous state. Great authorities have defined it, with apparent precision, to be a chemical body, which may exist as a volatile vapour,* in a solid state, or dissolved in fluid. With a still more decided appearance of precision, the contagious poison has been pronounced to be an *albuminoid matter* in a state of rapid chemical change, which has not yet been isolated. Thus, the Cattle Plague Commissioners expressed the opinion that the poison of that highly contagious malady was probably matter "of a kind which is, and always will be, undiscoverable by the microscope." They remark "that

* The view that some contagious poisons are *volatile* seems to have been adopted because it has been found that the disease could be propagated through air and by the breath of the affected man or animal, but such a conclusion is unjustifiable, for, as is well known, particles as large as starch globules can be wafted from place to place by currents of air, and these are not *volatile*. Moreover, multitudes of insoluble particles, of determinate size, always exist, buoyed up by the ordinary air on the surface of the earth. But solid particles should not be called *volatile* unless they can be converted into vapour which, by condensation, again assumes the general form and state the particles first exhibited.

chemistry has as yet (1866) found in Cattle Plague no complex albuminoid matter in a state of rapid chemical change, capable of communicating its own action to the albumen of the serum of the blood, and of the textures of cattle." The author of these sentences, unwittingly perhaps, expounds the doctrine he himself believes, and desires the public should adopt. Though he admits that chemistry has not found the matter, he intimates that ere long success may be attained. On the other hand, he has no hope whatever that the microscope will ever assist in the discovery of the poison. The poison is *always to remain undiscoverable* by this instrument! Here is one mode of investigation authoritatively condemned without reason and without knowledge on the part of him who condemns it, and another exalted with unmistakable affection and partiality, although its shortcomings are admitted. At the very time these sentences were written, the poisonous matter *had been made out* by the microscope, and the contagious material of more than one contagious malady had been actually figured in the report which is here criticised, and which the writer is supposed—for he does not hesitate to comment upon it—to have read and studied.

Those who are acquainted with the theories now entertained upon this very important and interesting question, know that many of them are based upon the results of microscopical enquiry. There are

indeed no other means of investigation yet discovered which afford equal prospects of success. Moreover, by this method of enquiry important results have been already obtained. It was therefore unfortunate that microscopical investigation should have been condemned by the authority of a Royal Commission, and the suggestion offered that chemistry was likely to succeed in detecting particles of matter which it is only possible to discern by the aid of very high magnifying powers employed with due care.

Notwithstanding the publicity given to many mere physico-chemical theories and the energetic means taken to force them into popular favour, the view that the poisonous matter of self-propagating (Dr. Budd) diseases, really consists of some kind of living substance (germinal or living matter), has been steadily gaining ground, although it must be admitted that many of the statements which have been made in its favour are of the vaguest and most unsatisfactory description. Thus many persons seem to have adopted the strange notion that dust is made up of disease germs. The harmless ingredients of this material have been spoken of as if they were disease-propagating particles of the most terrible kind. The innocent organic fragments detached from our carpets and rugs and dresses and furniture, have been treated as if they were contagious.

Of those who accept the *germ theory of disease*, some hold that the living particles which grow and multiply

in various kinds of decomposing organic matter, are derived not from germs floating in the air, but have been built up *ab initio*—result in fact from spontaneous generation or heterogenesis. These think to fortify their position, which indeed sorely needs even an appearance of strength, by such remarks as the following:—"There is not a physiologist of eminence who would deny the possibility of the origin of organic forms direct from the inorganic, while many are convinced of the truth of the doctrine," and so on,—as if this sort of statement could in any way influence the judgment, or help the elucidation of the truth as regards the question at issue.

On the other hand, it is not uncommon to find writers in our journals affirming with the utmost confidence, that these so-called *germs* are fictions of the imagination, that they have never been seen, and that the air, which by some is said to teem with disease germs, is entirely free from them.

Some authorities have opposed the germ theory of disease by the argument, that if the supposed germs really did exist, they would certainly exhibit well-marked distinctive characters. But there is no ground whatever for the opinion that the particles which are instrumental in propagating contagious diseases, if living, should exhibit specific structural peculiarities. That the several kinds of contagious matter of small-pox, scarlet fever, and other eminently contagious maladies, are distinct, each being imbued with its

own specific and peculiar power, is demonstrated by observation, but that this difference in power or property should be associated with any recognizable difference in appearance, form, chemical composition, or any physical characters, is exactly what a careful examination of the facts, and a judicial weighing of the evidence, would not lead us to anticipate. If, indeed, these poisons really consist of living matter, analogy would lead us to conclude that they would not be distinguishable from one another, except by the effects they produce. For we cannot distinguish one form of healthy living matter from another. The living matter which produces nerve, or muscle, or bone, is just like—at least as far as we can ascertain—that which gives rise to cuticle or to cartilage? Though the results of the life of these several kinds of living matter are so very different, the matter itself appears similar in all cases ; and, examine it as we may, we cannot discover any distinguishing marks. Nay, the living matter of one animal is like that of another. No form of animal living matter can be distinguished from the living matter of a plant, or from that of any of the lowest simplest forms of existence. Discarding the results of observation, some writers have indeed maintained that the anatomical elements or cells of morbid growths have peculiar characters of their own, and can invariably be distinguished from those of healthy structures ; but repeated failure of the attempts to do so on the part of those who held that the distinction

existed, necessitates a modification of this view. But even if characteristic differences could invariably be pointed out in the anatomical units or cells, it is quite certain that the *living matter* of the most virulent cancer, or of the most inveterate contagious malady could not be distinguished from that of the harmless growth, or healthy tissue at any period of its existence.

The old doctrine, that the disease-carrying particles, are germs derived from and capable of producing microscopic vegetable organisms, has been recently revived and extended. Since the investigations of Pasteur, and the publication of the observations of Salisbury and others, the *vegetable* or *fungus germ theory of disease* has received a large accession of advocates. According to this view, there are different species or varieties of fungi corresponding to the several contagious maladies with which we are familiar.

We must not, however, conclude that if disease germs really do consist of living bioplasm or germinal matter, they must necessarily be of a vegetable nature and have sprung from vegetable organisms, or have originated spontaneously, for it is obviously possible that, though *living*, their nature may be very different, and that they may have been derived from a different source. While I freely admit that the facts of the case are conclusive as regards the living state of the active matter of contagious diseases, I am quite unable to

subscribe to the arguments advanced in favour of the *Vegetable Germ Theory of disease.*

But it is time we should pass on to consider what is the nature of the supposed *germs* to which contagious maladies are now attributed. If the opinion is very generally entertained that the *materies morbi*, the *virus*, or *contagium*, of contagious diseases consists of germs which are introduced into the organism, the exact nature of the germs in question, at any rate is the subject of much discussion, and, indeed, the nature of germs generally, as well as the question of origin of these bodies, and the manner in which they act has given rise to many different theories. And surely it is a point not only profoundly interesting, but of vast practical importance, and worth any effort, to determine, whether the germs upon which the communicability of contagious diseases alone depends, are certain species of low simple organisms of definite character, produced in the outside world independently of man, or are bodies which have originated in man himself, and are to be regarded as degraded forms of living matter, derived by direct descent from some form of human living germinal matter or *bioplasm*. If the first supposition—and this is the favourite doctrine at this present time—should turn out to be correct, there appears much less hope of extirpating the diseases the germs produce, than if the last-mentioned theory, or some modification of this, should turn out to be true.

Of a Germ.—The term *germ* can only be correctly applied to a particle that is *alive;* but there are multitudes of different kinds of germs. It used to be supposed that the germ grew in a manner peculiar to itself; but we now know that however varied may be the substances resulting from the changes taking place in germinal matter, every kind of this living material, at every stage of existence, *grows* essentially in the same manner, though at a very different rate. The living particle which sprouts from a cell of the adult plant or organism, and is then detached, may be called a *germ,* as well as the living particle formed in the ovum, or the living matter in the ovary from which the new being is evolved. Any living particle growing or capable of growth, may be termed a "*germ.*" Every *germ* comes from living or germinal matter, and from this only. A particle of living matter, less than the $\frac{1}{100{\cdot}000}$th of an inch in diameter, is a living germ, Figs. 1 to 8, plate I. It may take up lifeless matter, and convert this into living matter like itself, and thus *grow.* It may then divide and sub-divide, and thus a mass of considerable size may result. The original *germ* may give rise to successive generations of new particles, "germs" having similar powers or properties; or from it may emanate higher types of organization, having special formative powers, from which new germs may or may not proceed. So that a *germ is but a particle of living matter, which has*

been detached from already existing living matter, and this living matter came from matter of some sort which lived before it.

Of Bioplasm.—Hitherto, I have employed the simple term *germinal or living matter*, to denote the active matter which is alone instrumental in the formation of all living beings and their tissues and organs; but this term is lengthy, and, in some respects awkward, and inconvenient. It cannot be used alone when speaking of a single particle, nor can it be employed adjectively. The word *Protoplasm* has been much used for some years past, but the vagueness attached to it is fatal to its employment here. A word is wanted to denote living, forming, growing, self-producing germinal matter, as distinguished from matter in every other state or condition whatever. Now protoplasm has been applied, both in this country and in Germany, to *lifeless* matter as well as to *living* matter, to *formed matter and tissue* as well as to the *formative* matter. And quite recently, Prof. Huxley and others have added to the confusion by giving it a still wider signification—so very wide, indeed, that almost anything that ever formed part of an organism may be called protoplasm. Roast mutton, white of egg, and a number of other things living and dead, having structure, as well as structureless, are said to consist of protoplasm; so that the word may include almost anything, and is not applied to matter in any particular state. It becomes, in fact,

useless. The term I propose to apply to the *living* or *germinal self-propagating* matter of living beings, and to restrict to this, is *Bioplasm* (βιος, life; πλασμα, plasma). Now that the word *Biology* has come into common use, it seems desirable to employ the same root in speaking of the matter which it is the main purpose of biology to investigate. *Bioplasm* involves no theory as regards the nature or the origin of the matter. It simply distinguishes it as *living*. A living white blood-corpuscle is a mass of bioplasm, or it might be termed a *bioplast*. A very minute living particle is a bioplast, and we may speak of living matter as bioplasmic substance. A cell of epithelium consists of *bioplasm* or bioplasmic matter, surrounded by *formed non-living* matter, which was however once in the *bioplasmic state*. In the same way an oval yeast particle consists of the *bioplasm* with an envelope of *formed material*, which has resulted from changes occurring when particles upon the surface of the bioplasm died. The bioplasm of the microscopic fungus or other organism may give off diverticula which may become free independent *bioplasts*. Each minute bioplast may grow, and in the same way give rise to a number of other bioplasts.

The mode of growth of the *bioplasm*, and the manner in which it undergoes conversion into *formed material*, will be understood if Figs. 9 to 12, plate II, p. 20, be attentively examined. In Fig. 12, the bioplasm is growing very rapidly at the extremity of each

of the branches of microscopic fungus figured. Here it has imbibed much of the carmine employed to stain it, and thus render it distinct, and is coloured with the greatest intensity. The formed material in this situation is thinner than elsewhere, sufficient time not having yet elapsed for it to become of the ordinary thickness which it exhibits in that part of the branch which is fully formed. The formed material is thickened by deposition, layer within layer, in the manner shown in Fig. 9 *a*, and as will be again referred to further on. (See page 16.)

In order to form a general notion of the nature and properties of living germs which consist partly or entirely of *Bioplasm*, it will be necessary to consider carefully what takes place when a very simple organism grows. I propose, therefore, in the first place to discuss the question of the formation of the yeast fungus or yeast cell. The organism is so common that any one can easily obtain it and study for himself the phenomena which will be referred to. This will form a good introduction to the consideration of the *vegetable germ theory of disease*, which will clear the way and prepare us for the full consideration of the highly interesting but complex question of the nature and origin of the contagium, or virus, of contagious or self-propagating diseases.

OF VEGETABLE GERMS.

Of the Yeast Fungus.—If on a warm summer's day or in a warm room a piece of germinating yeast about the size of a pin's head be placed upon a glass slide, covered with very thin glass and gently pressed, so as to form a very thin layer, and then examined under a microscope having a magnifying power of about 300 diameters or upwards, numerous little transparent, colourless, oval bodies will be seen all over the field. The bioplasm of these may be coloured by carmine (Figs. 6, 7, 8, plate I.). They vary in size much more than is generally represented in published drawings of them, and many are joined together. If the stratum of yeast be made very thin, as may easily be effected by firm even pressure upon the thin glass, numerous very minute bodies will be observed amongst the well marked yeast corpuscles. The yeast consists of the distinct oval bodies, the minute particles (detached germs), and a fluid in which both are suspended.

If now the apparently smooth oval bodies be subjected to examination under a still higher power (1,000 diameters, or upwards), many of them will be found to exhibit little eminences, which project from various parts of the surface. Sometimes only one such eminence, and sometimes as many as a dozen, may be counted in connection with one oval yeast cell (Fig. 7, plate I.). These are undetached germs;

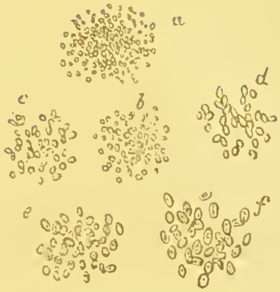
and if the yeast cells be kept under the field of the microscope for some hours at the proper temperature, and then examined again, the little projections already adverted to will be found to have increased in size, and *some will have detached themselves from the parent yeast cells.* Thus the minute bodies (germs) suspended in the fluid portion of the yeast have arisen from yeast cells which existed before them. The little eminences or projections are, in fact, buds or germs formed by the yeast cell, and when detached, constitute new yeast plants, and thenceforth become independent organisms. Each germ or bud was for some time connected with the parent cell, from which it originated. The very material of which it consists was continuous with that of the parent. The matter of which it was formed, in fact, formed a part of the parent mass, as is well seen in Figs. 7 and 8, plate I., page 16. Once detached, however, each little germ becomes an independent living thing, and never joins again the particle from which it emanated. Many of these germs detached are represented in Figs. 7 and 8. The free germ may multiply while it remains in the *germ stage of existence*, or it may grow into the likeness of its parent if supplied with the proper nutrient material and placed under conditions favourable for its advance to a higher stage of its development.

Of a single yeast particle and of its Bioplasm and formed Material.—If a single yeast cell be carefully

examined it will be found to be composed of two different kinds of matter, the one smooth, *transparent* and *external*, forming a membrane closed at all points, and commonly known as the *cell wall* (formed material), the other *soft*, *diffluent*, also *transparent*, but apparently composed of *semi-fluid* matter (*germinal matter or bioplasm*). If the yeast cell be firmly pressed between glass plates it will burst, and the contents will be squeezed out as soon as the rupture of the protecting envelope has been effected. This envelope or cell wall varies in thickness in different cells, being firm and thick in the oldest, and so thin as to be demonstrated with difficulty in the youngest cells. The envelope itself is formed not by the deposition of matter from the surrounding medium upon the surface of the cell, but from the soft diffluent bioplasmic matter within. This envelope is thickened by the formation of new formed material from the bioplasm which is deposited layer within layer upon the inside of the already formed capsule, cell wall, or envelope (Fig. 9 *a*, plate II.). The germinal or living matter or bioplasm, can be coloured with an ammoniacal solution of carmine, while the formed material remains perfectly colourless. This fact is shown in the figures which have been coloured so as to resemble the specimens from which they have been carefully copied (see Plate I., figs. 6, 7, 8; plate II., figs. 9 to 12).

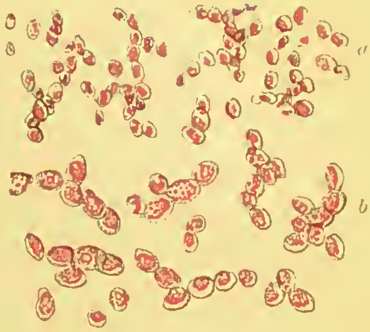
Of the production of the minute Yeast Germs.—Now, how are the little *buds* or *offsets* or *gemmules* of the

Fig. 1.



Development of germs in organic fluid. *a*, 12 hours after their first appearance. *b*, one day. *c*, two days. *d*, four days. *e*, five, and *f*, six days. × 215. p. 10.

Fig. 6.



Yeast cells, growing during forty-eight hours *a* × 215. *b* × 400. pp. 14, 20.

Fig. 2.

Bacteria germs from the mouth. × 1800. p. 34.

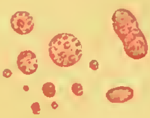
Fig. 3.

The same. × 3000. p. 34.

Fig. 4.

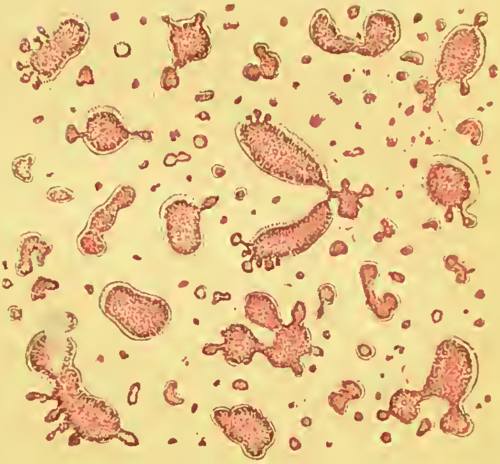
The same. × 5000. p. 34

Fig. 5.



The most minute germs of fungi visible under the $\frac{1}{50}$. The smallest is much less than the $\frac{1}{100000}$ of an inch in diameter p. 34.

Fig. 7.



Growing yeast cells, showing diverticula from each mass of the bioplasm. These are from time to time detached each germ when set free may grow and produce others × 1300. 1867. pp 14, 19.

Fig. 8.

Growing yeast cells and most minute germs, well stained with carmine and magnified by the $\frac{1}{50}$ = 2800 diameters. p. 14. Nov., 1869

$\frac{1}{1000}$ of an inch —— × 215 linear.
$\frac{1}{10000}$,, ,, —— × 1800.
,, ,, ,, ——— × 2800.
,, ,, ,, ———— × 5000.

[To face page 16.

yeast plant formed? Do they result from the growth of the external envelope with which they are certainly for a time connected, or is the soft diffluent material within concerned in their production? This question can be answered conclusively from direct observation. Never do we find a bud which does *not contain some of the soft diffluent germinal matter; never one composed of the matter of the envelope only* (Figs. 7, 8, Plate I.). In the formation of these buds a very small portion of the soft material protrudes through minute pores in the envelope, perhaps pushing a very thin layer of this latter before it, through which it imbibes nutrient matter from around. It soon increases in size forming a little nodule or button which remains for a time connected with the parent mass by a very narrow pedicle (Fig. 8, Plate I.). This pedicle consists externally of matter like that of which the envelope or cell-wall is composed, but in its centre may be traced a very thin line of bioplasm, by which the bioplasm or germinal matter of the bud remains for a time connected with the parental bioplasm. This line cannot be discerned in every instance, but from the numerous observations I have made I do not believe it is ever absent at this period of growth. I have seen the diverticulum of germinal matter in so many cases already projecting from the general mass, that I feel sure the above description is correct. When multiplication is going on with great rapidity, the mode of formation of the buds may in fact be demonstrated

with the greatest certainty, as represented in Fig. 8, plate I.

The material of which the cell wall consists (formed material) passes gradually into the germinal matter, when the plant is germinating quickly, and the abrupt line, which marks the internal boundary of the capsule in many specimens, is absent. These points are given in the drawings, Figs. 7 and 8, the latter, in which the formed material is made too thick, taken from a specimen magnified by the fiftieth.

Where growth is active, the yeast cells are embedded in a soft material continuous with the external surface of the envelope, as represented around the yeast particles in the central part of Fig. 8. This probably consists partly of matter which is drawn towards the surface of the cells by the currents of fluid which are setting towards the germinal matter within, and partly of imperfectly hardened formed material. Thus there always appears to be a space between the outer part of one and the outer parts of neighbouring cells.

The very soft material, which consists of imperfectly formed matter, that by gradual condensation assumes all the characters of the cellulose wall of the yeast particle, corresponds to the mucus which lies between the particles of bioplasm concerned in the formation of that substance, and bears the same relation to the envelope of the yeast cell as the viscid mucus does to the wall of an epithelial cell embedded in it.

When yeast has been successfully stained with carmine fluid it forms a beautiful object for investigation, and with the aid of very high powers many points of the greatest interest may be discovered. The cells represented in Fig. 7, plate I., were growing very rapidly. Protrusions or outgrowths are seen projecting from every part of the bioplasm, and in some instances the latter appears to have been preserved while it was in the very act of moving. I have specimens of the bioplasm of mucus, of epithelium and of cartilage, which illustrate the same point. In every case the continuity of the bioplasm of the little outgrowth with the general mass within the cellulose wall can be well seen. In Fig. 8 are represented some of the smallest and simplest of the yeast particles under a magnifying power of 2,800 diameters, the $\frac{1}{50}$ of an inch object glass. Both these drawings illustrate the mode of formation of *germs* in this very simple organism, and it will be shown in another part of this work that the bioplasm of man and the higher animals gives off diverticula in much the same manner; and that these when detached become free bioplasts.

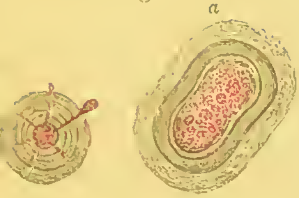
The diffluent germinal matter within the yeast cell is the material upon which alone all growth and action depend. Were it not for the bioplasm or germinal matter the cell would be lifeless and passive—incapable of "exciting fermentation" or any change whatever. Every particle of the bioplasm is living, and may, under favourable circumstances, undergo develop-

ment into complete yeast cells, so that by the artificial division of one, thousands may result. And if the soft bioplasmic matter which can be expressed from the yeast cell be placed under favourable conditions, every particle of it may germinate. This matter alone furnishes the germs, it alone grows and appropriates the nutrient material, in short it alone manifests phenomena peculiar to living things.

The little buds or gemmules above referred to, detached from the parent mass, and capable of independent existence, are, many of them, much less than the $\frac{1}{100,000}$th of an inch in diameter. But each is living and will grow, under favourable circumstances, into a body like the parent cell, giving origin in its turn to countless descendants. These very minute particles divide and subdivide independently, producing still more minute particles, capable of growth and division like themselves, not one of which, however, may be developed into an ordinary yeast cell like those represented in Fig. 6, plate I. This mode of multiplication may go on for a long period, perhaps for an indefinite time, if certain conditions persist. But if any one of these excessively minute particles falls into a medium containing suitable pabulum, it will appropriate it, and soon pass on to a higher stage of development. In this case branches may be formed, as represented in Fig. 11, plate II., and more advanced in Fig. 12. See also Plate III., fig. 22. From them may proceed stems which grow upwards into the air,

GERMS.—FUNGI.

Fig. 9.

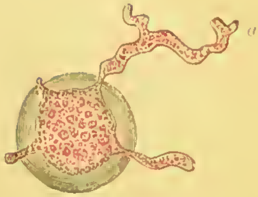


Old spores of fungi, in which the formed material has become very thick. At *a* the bioplasm is passing through pores. Its further growth is given in Fig 10. × 1800 pp. 12, 16.

Fig. 10.

Germs of fungi, showing the relation of the bioplasm to the formed material and the production of the latter from the former. × 1800. p. 22.

Fig. 11.



Passage of bioplasm through pores in formed material, showing the manner in which the branching stems of fungi are formed × 1800. p. 20

Fig. 12.

The extremities of a branching stem of a rapidly-growing fungus from jam. At the apex, where the cellulose wall is only just forming, it is so thin as to be hardly demonstrable. The germinal matter in this situation is abundant, and it is here principally that growth takes place. × 215
a, a spore which has just commenced to sprout. × 500. 1869. pp. 12, 21.

Fig. 13.

Most minute bacteria growing and multiplying Shown in outline. × 2800. pp. 21, 34.

Fig. 14.

Germs of bacteria, growing and multiplying rapidly × 1800. 1865. pp. 21, 34.

$\frac{1}{1000}$ of an inch —— × 215 linear.
$\frac{1}{10000}$ " " —— × 1800.

[To face page 20.

and bear upon their summits heads in which spores are formed, these last being so well protected from the influence of destructive agents, that the germinal matter within can retain its vitality for a great length of time. Fig. 10, plate II.

GERMS IN THE AIR.

The spores just referred to are so light as to be easily supported in the atmosphere, and they may be carried a long distance by currents of air. The infinitesimal germs before adverted to are of course transported still more readily. Some of these are represented in Fig. 1, plate I., and some of the most minute that can be discovered with the highest powers of the microscope, in Figs. 1 to 5, and in Figs. 13 and 14, plate II. Bodies weighing 100 times as much as these can be supported in air. There is, therefore, no wonder that germs so very small and light are almost constantly present in our atmosphere. Myriads no doubt perish for one that falls in a spot where it meets with suitable food and other advantageous conditions. It is not to be wondered at that such minute germs as these should exist almost everywhere, floating in the atmosphere, deposited upon everything, and ready to undergo development wherever the conditions may be favourable. And the vitality of the bioplasm of lowly organisms of the kind under consideration is so great, that protected as it is by its external en-

velope of formed material, it is able to resist effectually and for a long time the disturbing influence of adverse external conditions. Should these lead to the death of a great part of the living matter or bioplasm, it must be remembered that by this very change, the thickness of the external envelope is increased, and thus the speck of living matter which remains, becomes still more effectually protected than it was at first (see Figs. 9 and 10, plate II.).

Protected in this way, multitudes of such germs escape destruction. Provided only a speck of living matter remains, and resists the influence of adverse conditions, it will increase undei favourable circumstances. Particles will make their way through pores in the envelope, and coming into contact with the pabulum outside will soon increase and develope minute germs or branching stems as represented in Figs. 11 and 12.

Of the Detection of Vegetable Germs in the Air.—Vegetable germs were detected in the air more then twenty years ago by a number of observers, and by many different plans of procedure. One method was to cause air to be drawn through a glass vessel, the outside of which was cooled by ice. Upon collecting the water which condensed upon the interior in a vessel placed beneath for its reception, and examining under the microscope the slight sediment which subsided, the germs were discovered. Another plan was to cause air to be projected against glass plates, the surface of which had been wetted with weak glycerine,

water, or some other substance, to which the particles would adhere; or merely to hang up such plates in the air for a time. Some observers employed paper moistened with the same fluids. Pasteur investigated the matter very carefully, and showed that the number of germs existing in the air varied much in different places and at different heights. He also found that the air which had been undisturbed for some time in cellars was almost destitute of germs. Mr. Crookes followed a plan which had been previously adopted by Schrœder, and separated germs from the air by filtering it through pure cotton wool. He also collected the germs in tubes, and upon glass slides moistened with glycerine (Cattle Plague Report, 1866). It would be generally concluded that many of the germs suspended in air and capable of being wafted long distances by currents, would subside if the air became perfectly still, just as the dust in our rooms falls upon the floor or is deposited upon shelves and other projections. Dr. Tyndall has, however, considered it necessary to *demonstrate* the fact that tiny particles of dust really do fall down to the ground if the air in which they are suspended be quiescent. By throwing a ray of very bright light upon air contained in a closed chamber of glass 3 ft. by 2 ft. 6 inches, and 5 ft. 10 inches high, tapering to a truncated cone at the top, he was able to prove not only that particles of dust which float in the air for a time after it has been disturbed gradually subside, but that these were

deposited upon the sides of the chamber as well as upon the floor. "The chamber was examined almost daily ; a perceptible diminution of the floating matter being noticed on each occasion. At the end of a week the chamber was optically empty, exhibiting no trace of matter competent to scatter the light." This experiment is calculated to convince any one who doubts the fact that particles of *lifeless* matter, even when very minute, really do tend to fall through air, until they reach some resting place which prevents them from falling still lower, and the great discovery is announced that ponderable bodies are ponderable. But the demonstration determines nothing whatever with regard to *living* particles, not even their presence.

Dr. Tyndall also makes a prediction concerning the discovery of the cause of the impotence of certain air as a "generator of life," as if *air*, which is lifeless, could under any circumstances *generate* that matter which lives. Has any one been educated into a belief in the *life-generating* properties of the air ?

The nature of the materials which make up the dust of our air is a subject which has often engaged the attention of microscopists, who have long been familiar with the fact that multitudes of organic particles derived from various sources are floating in the more or less disturbed air of our rooms. Many of these fall into our microscopic specimens while they are being mounted, and in spite of all our care, and

the use of glass shades and other means, we often preserve portions of hair, feathers, scales of the wings of insects, and a number of other foreign bodies which we would gladly exclude from our preparations. The characters of these organic particles are but too well known to us, and probably hundreds of microscopists have many times examined the dust which commonly collects upon shelves and little projections from the walls of our rooms, for the very purpose of demonstrating the many different kinds of organic fragments of which it is in great part composed. Memoirs have been written upon the extraneous matters which fall into urine, sputum, and other secretions which it is the business of the physician to examine. These extraneous particles which have been deposited from the dust suspended in the air of the rooms have given rise to great confusion, and some of them have been mistaken for bodies derived from the organism of man. No wonder, therefore, that much attention should have been given to the examination of dust, and in order to prevent mistakes figures of some of the most important constituents of dust have been given.* Particles of hair and wool of various kinds, filaments of cotton and silk, portions of insects, especially the scales of the common clothes-moth, starch granules, pollen grains, fragments of wood, and animal and vegetable germs, are among

* See for example "How to Work with the Microscope," 4th edition, p. 195, Plate XLIV.

the many organic constituents of dust which are familiar to microscopical observers. Pouchet found in the dust of the air (*Comptes Rendus*, March 21st, 1859), "the detritus of the mineral crust of the earth, *animal and vegetable particles*, and the minutely divided *débris* of the various articles employed in our wants." Mr. Samuelson, many years before 1863, obtained living germs from dust taken from the window panes, and from other common-place localities, and gave numerous figures of the different forms he discovered ("On the Source of Living Organisms," Quarterly Journal of Science, Vol. I., p. 598). Many other observers have also examined dust of various kinds with great care, and have described the organic particles existing in it in great numbers.

Yet in spite of the numerous observations which have been made and published upon this subject, we find Dr. Tyndall teaching the public in a lecture on "*Dust and Haze*," given at the Royal Institution on Feb. 18th, 1870, and afterwards published in several newspapers, that he had only just discovered that the dust of our air contained *organic particles*. His remarks were afterwards more widely diffused in several journals under the title "Dust and Disease," no connection whatever having been shown by the lecturer to obtain between disease and dust or between either and germs. Dust may certainly be perfectly harmless.*

* Witness the cavalcade of picturesque stalwart women crossing Hyde Park every evening on their way from the dust-heaps at Paddington, to

On the other hand, is it impossible that disease germs may exist free from dust?

Dr. Tyndall had thought "with the rest of the world, that the dust of our air was in great part inorganic and non-combustible." But from the "rest of the world" must be excluded the majority of those who have used a microscope or are acquainted with the use of this instrument. Ought a lecturer to excite the astonishment of his audience by trying to convince them that until lately he was quite unacquainted with some things very generally known, and when his hearers have become sufficiently interested in this want of information on his part, relate as some new discovery what he has happily to introduce to their notice? Dr. Tyndall has discovered that the little particles of cotton and hair and wool and feathers and other organic substances which exist in the air, can be destroyed by a red heat and converted into smoke, which would not be the case had they consisted of inorganic matter as he supposed before he tried the experiment he proceeds to repeat.*

their homes at Westminster. Whatever may be said against them, they are evidently persons in rude health and more affected by the passive organic and inorganic constituents of the dust than by its active disease-producing germs.

* Dr. Tyndall, after the publication of his lecture, announced in the "Times," that Dr. Percy had discovered that the dust upon the walls of the British Museum contained 50 per cent. of inorganic matter—this, in support of Dr. Tyndall's belief, that the dust of our air was in great part inorganic and non-combustible. But Dr. Tyndall says nothing about the nature of the remaining 50 per cent. of this dust.

But more than this, Dr. Tyndall professes to be able to bring " the air of the highest Alps into the chamber of the invalid." This grand result he proposes to achieve by causing the dusty air to traverse cotton wool, by which operation the dust which had been demonstrated together with the germs supposed to be mixed with it are filtered off. Even Dr. Tyndall will scarcely be inclined to deny, after a little quiet reflection, that the promise to bring Alpine air into the London sick rooms, may appear to unromantic people who actually attend upon invalids more like the result of emotional excitement than a conclusion deduced from any exact methods of observation or experiment.

By the physical method of examination, particles of wool and cotton and hair, scales and other particles from insects, and starch and soot, and all the other constituents of dust, alive and dead, organic and inorganic, are illuminated so as to form one confused ray, which can be seen at a great distance; but, it need scarcely be said, the brightest light the physicist can cause to beat upon them fails to reveal the nature of the several dust particles, or enable anyone to distinguish the living particles from the lifeless *debris;* or the virulent disease germs, should there be any, from the harmless dust. Now, instead of burning all the organic matter together, the living and the lifeless with the non-living, including that which exhibits form and structure, and that which is formless and structureless,

and demonstrating the smoke resulting from the destruction of all, any one with the aid of a microscope in less time, with less trouble, without complicated apparatus, might have quickly demonstrated, and with the greatest precision identified the various kinds of organic particles present in that particular specimen of dust, and he could have shown the particles themselves instead of the smoke which resulted from their combustion and destruction. In short, the method of burning dust proves only what can be proved quite as positively by much simpler means; and proves absolutely nothing regarding the existence of disease or other germs in the air—a subject which has been successfully studied during the last ten years or more by other methods of inquiry. It is difficult to imagine anything further removed from fact than the statement that the dust of our air consists of disease germs. No one would dare to make such an assertion in plain words. It would be nonsense. And yet remarks have been made which have undoubtedly led the public to infer that such a conclusion was implied, or that it was desired that such an inference should be drawn. It is, however, still more astonishing that writers in some of our leading journals should be so misled as to give, without comment, an interpretation of an author's views which amounts to absurdity. Thus the "Academy" (April 9th, 1870, p. 185), in referring to Dr. Tyndall's lecture on Dust and Disease remarks, "The floating dust-like matter

revealed in the air by a sunbeam is *organic, probably germs of animal and vegetable life.*"

In a subsequent letter to the "Times" (April 21st), Dr. Tyndall says that the organic matter of London air is not all "*germinal matter!*" The lecturer has spoken of germs, animalcules and germinal matter, but he does not explain whether these terms are used by him for the same thing or for different things. He speaks of the "morass of wordy discussion and contradictory argument," in which he says, without identifying the offender, "the germ theory of disease and the question of spontaneous generation are entangled," and with surpassing simplicity he assures the editor of the "Times" that he is "unpledged to more than a clear statement of the germ theory," and refers to the exactness of physics and chemistry, and to the methods by which he proposes to detach "from the domain of vagueness and uncertainty each successive fragment of demonstrated truth!"

In common fairness, Dr. Tyndall should have studied the matter a little before he gave his first lecture, instead of in his last characteristically excusing himself on the ground of "tenderness for the public,"* for not alluding to the researches of others, and for with-

* The considerate tenderness which, as a rule, is reserved exclusively for the public, is, it must be admitted, on one occasion extended towards an individual. Dr. Tyndall did indeed admit that he could not read without "sympathetic emotion" the papers of an observer, whom, however, a stern sense of justice compels him to regard as "a man of strong imagination"—as one "who may occasionally take a

holding from the press statements concerning these which he had "twice or thrice written down." Had he done so, there would be less reason to condemn or to laugh at the following paragraph with which he concludes his last letter to the Editor of the "Times," and retires for the present from the consideration of dust, disease, and germs. "For a long time to come I shall be unable to devote any attention to this subject, and this has caused me to write at what I fear you will consider inexcusable length: were the question of less practical interest to humanity, I should not have troubled you either with this or with any former communication."*

It would indeed be difficult to point out a series of conclusions less justified by the experiments.

flight beyond his facts!" but he tenderly observed, "as long as the heat (dynamic heat of heart by which alone the solid inertia of the free-born Briton is to be overcome) is employed to warm up the truth without singeing it overmuch; as long as this enthusiasm can overmatch its mistakes by unequivocal examples of success, so long am I disposed to give it a fair field to work in."—"Times," February 19th, 1870. Such comments are very curious, but they are not in good taste, and are altogether uncalled for and out of place. Dr. Tyndall had no right to speak in the way he has spoken of such a man as William Budd, of Bristol.

* Dr. Bastian has expressed his opinion of Dr. Tyndall's still more recent observations upon the influence of germs and animalcules upon disease as follows:—"The question is, however, one of so complicated a nature, that little save amazement will be excited in the minds of those conversant with all the difficulties of the problem, that Professor Tyndall should place so much reliance upon indirect evidence towards its solution, and should step forward on the strength of this, with the view of establishing a doubtful theory of disease, to which he, by his own confession, has so recently become a convert."—"Times," April 13th, 1870.

It is difficult to see in what way Dr. Tyndall's experiments illustrate or affect any sort of germ theory. They could all have been made without a single reference to germs of any kind or to a germ theory or to disease. On the other hand, these last subjects might have been rendered more intelligible to the unlearned if their attention had not been diverted by the brilliant illuminations and combustions.

The *method* is defective. The Professor first points out that he supposed that dust consisted of inorganic particles. He discovers to his surprise that it contained organic matters. Next he seems to wish that his audience should regard these organic matters as germs or animalcules, or at any rate look upon some of the particles of dust as composed of "germinal matter." But Dr. Tyndall did not demonstrate what the organic particles in air were, nor did he prove that dust contained anything whatever that would give rise to disease. The particles might have consisted entirely of harmless germs, or of disease germs or of animalcules, or there might have been a few of these bodies present, or there might not have been a vestige of any of them, and Dr. Tyndall would not have discovered the difference by the method of investigation he employed, of the advantages of which he speaks so confidently. By his discoveries, surmises, assertions, and predictions published in the "Times" and other journals, people have been led to suppose that dust consists of germs, and that air teems with animalcules

and disease-producing particles, which is not really the case.

There is now a strong feeling in favour of scientific teaching. And branches of science, particularly those capable of illustration by experiment, are deservedly popular. But if the feeling in favour of scientific education is to be lasting, and not a mere fashion, and if it is desirable that the public should have any respect for science, her exponents must not put out what they have to teach in a sensational form. Undoubtedly the public may with good reason find fault with many of us for being slow and dreary, dry and uninteresting, and for presenting our lessons in a hard, unpalatable, not easily digestible form. But in endeavouring to escape these faults, it is very undesirable that any tendency towards the gushing and hysterical or rhapsodical, should be permitted. Our object it must be distinctly understood is to teach, and not to excite or surprise or amuse. There are theatres, and in great number, established for the very purpose of affording amusement where we may enjoy excitement and wonder and surprise to our heart's content, but the scientific workroom is built for instruction and for real earnest work.

The Characters of the most minute Vegetable Germs.—The very minute vegetable organisms which may be obtained from the air, and which are developed in infusions of animal and vegetable matter, are for the most part of an oblong oval form, frequently exhibiting a constriction which corresponds to the point of

division (see Fig. 20, plate III.). Some are, however, much more elongated than others. Compare Figs. 15, 16, 21, plate III., with Figs. 1, 2, 3, 4, plate I.; but whether these represent different species, or are merely variations due to the circumstances under which they have been developed, is not known. Sometimes a very elongated form is found amongst numerous short ones, Plate II., fig. 13.

The general appearance of minute germs of fungi multiplying rapidly in fluid favourable to their development, is represented in Plate I., fig. 1, under a power magnifying only 200 diameters. The most minute germs (bacteria) visible under the higher powers are seen in Figs. 2, 3, and 4, which are magnified respectively 1,800, 3,000, and 5,000 diameters linear. In Fig. 5 the appearance of very minute particles of bioplasm, which have been well stained with carmine and examined under the $\frac{1}{50}$, which magnifies 2,800 diameters, is represented.

Some notion of the manner in which the most minute germs multiply, may be formed if Figs. 13 and 14, plate II., opp. p. 20, be carefully examined. Whether there is any actual firm membrane around the minute particles of bioplasm represented in Fig. 14 is very doubtful. It is more probable that each little particle of bioplasm is embedded in a soft and semi-fluid formed material which has been produced by it. This, under certain circumstances, may become condensed, and thus an envelope or protecting

covering may be formed. The particles in Fig. 13 are only represented in outline.

The minute germs developed in infusions in closed vessels are represented in Figs. 17 to 20, plate III. These are referred to in page 49. But the somewhat definite characters manifested by these particles last mentioned, are not exhibited by the most minute germs discovered by the aid of the highest powers. These, like the most minute particles of other kinds of bioplasm, always appear as little specks of a rounded form. There is no possibility of identifying the different kinds of bioplasmic matter under the microscope. The most minute living particles of a vegetable organism exactly resemble those of an animalcule or those which may become developed into beings still higher in the scale; and in another part of this work it will be shown that these cannot be distinguished from particles of bioplasm derived from the living *mucus*, or *pus*, or *white blood*-corpuscles of man himself. Every kind of bioplasm at this stage of its being exhibits, as far as has yet been ascertained, precisely the same characters.

Of Germs of different kinds of Vegetable Organisms.—Of microscopic fungi and algæ there are many different kinds, which grow and multiply under very different external conditions, and live upon different kinds of food. Thus there are germs of numerous different species diffused through the air and wafted long distances at different seasons. Some flourish at

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a temperature which would be fatal to others; some live upon vegetable, some upon animal, matters. Some require solid substance upon and into which they may grow, while others seem to obtain from the atmosphere alone all the materials required for their growth and development. Some enjoy light, while others vegetate freely in darkness. Many of these vegetable germs are almost constantly diffused everywhere in the atmosphere, ready to increase a millionfold in a few hours whenever circumstances should be favourable. But all increase and grow in the same manner; all consist of the growing, living, active, moving *bioplasm*, or *germinal matter*, and a certain proportion of the passive, lifeless *formed material* around it, which has been already referred to.

It is supposed that germs of different species of vegetable organisms give rise to the phenomena in the system invaded, which are characteristic of the several contagious diseases, and by which they are recognized and distinguished from one another. In the germ stage, however, there are no characters which would enable us to determine the source of the germ; and whatever differences may exist in the fully developed state, at an early period of existence the embryonic living particles are alike.

It is not my purpose to direct attention to the various species of microscopic fungi which are known, or to discuss the vexed question concerning species and variety, or to indicate the variety of appearances

which may be assumed by one species, and which seem to be determined rather by varying external conditions and food than to be due to inherent specific powers. These questions are interesting and important enough, but I must now pass on to consider several points more intimately connected with the question concerning the origin of vegetable germs, and their supposed influence in causing disease.

Of the Origin of Vegetable Germs.—Several scientific authorities of high repute have of late summed up very distinctly in favour of the doctrine of the formation of living beings *directly* out of lifeless matter, without the instrumentality of pre-existing living matter. On the other hand, there are men well qualified to form an opinion who consider that the advanced minds of the present day have been led to strain facts more than was right, in order to make it appear that spontaneous generation, as well as some other doctrines correlated to this, ought to be accepted. The so-called "tendency of thought" has been adduced in favour of these views; writers of advanced articles in our magazines, distinguished for the brilliancy of their speculations, have written up the doctrine; and there is reason to think that no inconsiderable number of readers is desirous of being told, and is really anxious to believe, that living things may come direct from lifeless matter, and that force may build up structures and form organs without the assistance of intelligence, or the intervention

of creative power or other mysterious agency; and that matter requires but to be exposed to the influence of certain conditions in order to assume the living state. Nevertheless, every one admits that, in all the instances he knows about, the living being did, without doubt, come from a pre-existing living being. But, he proceeds to argue, because a *highly complex creature* cannot be formed direct from the dust of the ground, does it therefore follow that *all the simple living forms* modern research has brought under our observation have come from pre-existing simple creatures like themselves? Why, he asks, are we to assume that a simple structureless mass of jelly *must* come from a pre-existing mass of jelly? There must, he urges further, have been, at least in the beginning, a beginning of life. The living, at some time or other, did spring direct from the lifeless. If, then, it is admitted that this has happened once, is it unreasonable, he might ask, to conclude that it happened more than once, nay, many times, nay, he might remark, may we not feel sure that it has happened lately, and is going on daily and hourly?

It is very generally admitted that ever since life first appeared on our earth uninterrupted development has proceeded, and it is maintained by many that the evidence in favour of the view that the higher forms have been derived by descent from lower ones, is almost conclusive; and, it might be said by those who accept the doctrine, since "spontaneous

generation is still in operation, the lineal descendants of the simple beings which are now being evolved in vast numbers direct from the non-living, will, after the lapse of ages, during which progressive change shall never cease, become the parents of highly developed organisms totally distinct from any which have yet existed, and of which we, with our imperfect knowledge of the properties of the particles of non-living matter, cannot form even the faintest conception. But if our knowledge was sufficient, we should be able to determine now the specific characters of the creatures that are to be in the ages yet to come." May we not argue back with equal justice that the producer is greater than the thing produced, and that, therefore, we ought to go at once to the fountain head for life, which on this theory would be the simplest non-living matter? Further, it has been argued, "since we can trace a certain gradational relationship between the higher and the lower forms of living beings, we may consider it proved that the non-living is related to the lowest, simplest living in the same sort of way." The new philosophy, after affirming that the higher life passes by imperceptible gradations into the lower life, enquires, can it be possible that any one with intelligence should doubt for one moment that the lowest life passes gradually into the non-living? And modern philosophy boasts of her exactness, and professes to accept nothing that cannot be proved by observation and experiment. But

her disciples occasionally forget the iron rules they have laid down for others, and here, as in some other instances, after asserting that as the first position is proved, the second must be true, they just suggest that if not *proved* to be true, it is at any rate *capable of proof*, or if not actually provable just at this present time, is sure to be *proved to demonstration before very long!*

Any objection to such remarks as these, which are pronounced to be in harmony with the tendency of modern thought, are accounted frivolous. But, fortunately, or unfortunately, according to the stand-point taken, every one does not feel able to accept these arguments, and in spite of being considered foolish enough to attempt to oppose the whole tendency of modern thought, which is undoubtedly difficult, and perhaps impossible, I must, nevertheless, venture to remark that the doctrine of heterogenesis has not yet been proved to be true as respects one single living organism, and it is unfortunately the case that some of the "facts" which have been adduced in its favour are not facts at all, while of the "facts" some have been misstated and many misinterpreted.

He who does not accept the doctrine of the hour is, in these days, in danger of being denounced as a bigot, and stigmatized as *orthodox* because his rejection of the physical and sensational is held to prove him to be a bigoted believer in every antiquated doctrine that has ever been demolished by the bright light of research in the time that has passed. He is

also likely to be reproached as a heretic because he refuses to bow down to the phantom called the tendency of modern thought. But unreasoning credulity is not peculiar to old beliefs, neither is persecution. If the bigot of former days set physics at defiance, does not many a modern philosopher unquestionably attribute to physics phenomena which are altogether beyond the range of merely physical law? It is even doubtful if the unreasoning faith of the skilled scientific does not sometimes exceed the vulgar belief of the poor ignorant bigot. If the bigot is to be accused of believing in spite of reason, the sceptic of modern times sometimes exposes himself to the charge of justifying his disbelief by argument which has been proved to be false, as well as by advancing as a fact what is really but an assertion in a fact form. If the bigot may be laughed at for his belief in the unseen and unknowable, how is the modern enthusiastic believer in the omnipotence of the material to escape ridicule?

However absurd, and against all the accumulated evidence of observation, it may be to believe in the immediate creation of any particular species of complex plant or animal, it is at any rate equally absurd, and also *quite contrary to any evidence yet obtained*, to maintain that living forms result from the direct combination of particles of inanimate matter. And whatever may be said in favour of the uninterrupted continuity of life, and of the gradual alteration of living forms from age to age—all that has been proved

in connection with the growth and development of every class of living beings, tells against the doctrine of heterogenesis. And many who have written in its favour have convicted themselves of inconsistency, unless it be consistent to believe at the same time in the law of continuity and succession, and in a law which involves discontinuity and interruption as applied to the production of living forms at this present time.

I will, however, admit that upon such a question as heterogenesis, any one acquainted with the facts and arguments on both sides, and well accustomed to the marshalling of evidence in order, would, by a judicious selection of his facts, soon adduce evidence which would convince the unlearned of the truth of that view which he chose to advocate. Just at this time many circumstances have fostered in the public mind a demand for arguments in favour of the origin of living beings from mere matter independent of a superintending will. People have been so well educated that they do not recognise the oft-repeated assertion, that living beings are being continually made out of inanimate matter without the aid of already existing living beings, as a mere dogma, in direct support of which well authenticated facts and conclusive experiments cannot be adduced. That with some heterogenesis is accepted as an article of belief is not disputed here. There is no harm in this, but it must be distinctly denied that there is reasonable ground for the faith. And it is probable that the doctrine would have attracted very

little attention if it had not been forced into undeserved notoriety in consequence of the support it seemed to afford to modern matter-and-force views.

There has been far too much tendency of late to decide scientific questions by a show of hands. A very little tact is required to make a number of people who know little about the matter look with favour upon a new theory, for in their enthusiastic haste to upset old creeds of which they are tired, they are sure to neglect to ascertain whether the new one they accept is really as reliable as the old one they discard. But the cry " Hurrah for spontaneous generation," will not advance the cause, for happily, science is not like politics, in which people may take sides and settle things by acclamation, and action has to be determined by expediency and a number of considerations quite apart from the mere question of truth or of fact. In science, views are changed in no time, and theories most popular for a while are discarded the instant some new fact is revealed. Nothing can however retard scientific discovery more than the attempt to convert scientific deliberations into mere party questions. Science is open to all the world, and although excuses have been made for spreading inaccuracies on the ground that it was necessary to put the subject in a form to please unlearned persons—such excuses are utterly inadmissible. The unlearned public can understand any scientific question that is put before them clearly if they choose to take the trouble to

do so; and he who sacrifices accuracy to brilliancy and sensationalism offends in two directions, for he can have no respect for the intelligence of the people whom he really misleads, but is professing to teach, and he brings discredit upon science, gaining only for himself thoughtless applause. People who care very little about scientific investigation are encouraged to express themselves convinced of the truth of this or that scientific doctrine, just as vast numbers have believed in the truth of the table-turning, spirit-rapping, and other fanciful manifestations. They appeal to evidence which they assert to be convincing to their judgment, although the favourite views may be opposed to known laws, and be inconsistent with demonstrated facts.

That ninety-nine hundredths of the living beings on this globe should be derived from living beings that existed before them, while one hundredth, or one thousandth, or one ten thousandth should result directly from non-living matter, is very improbable; but because it is affirmed that such a view is "advanced," and in harmony with the whole tendency of thought, people do not stop to consider its probability or improbability. Continuity prevails as a law, but continuity is not to be universally applicable. Experience and observation demonstrate in thousands of cases that living matter is derived from living matter, and yet we are asked to believe that in some instances living matter comes from lifeless matter, because the

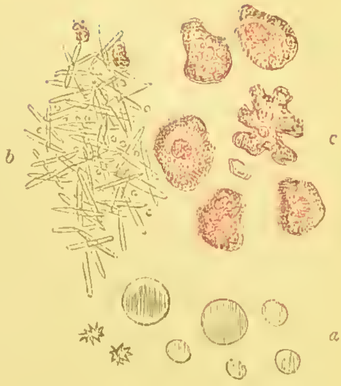
active and energetic minds of the day assert this. We are told authoritatively that we must believe that the non-living passes by gradations into the living, although the bodies supposed to establish the fact of these gradations exist only in the imaginations of those who make the assertion. It is unsatisfactory, if not useless, on the part of any one, however great the authority he wields, to declare that although substances in a state of transition from the non-living to the living cannot yet be produced, they *will be discovered at some future time.* Why are we to believe him? Of all prophecies the prophetic assertions of the scientific are the least worthy of belief, for the scientific spirit is utterly incompatible with the spirit of prophesy. No one can have so mistaken his calling in this world as the scientific man who ventures to prophesy, and yet the prophetic spirit seems to prevail in scientific quarters where it would be least expected. Even Professor Huxley cannot quite resist the temptation of foretelling what will be possible in a certain time. He says that he believes it possible before half a century has elapsed, that man may be able to take inorganic substances, such as carbonic acid, ammonia, water, and salines, "and be able to build them up into protein matter," and that that protein matter may "begin to live in an organic form." Of course he does not consider it necessary to give any reasons for such a strange opinion. It is supported by authority, but where are the facts which support it?

Not one of the many who have joined the ranks of the heterogenists has succeeded in giving us any conception of what, according to the doctrine he accepts, really occurs when the non-living matter becomes alive. No one who affirms spontaneous generation has ventured even to theorize upon this. Is it that the supporters of this view are at a loss to conceive what takes place, or are they afraid to commit themselves to an opinion concerning the rudimentary facts upon which the faith they profess to believe rests? What can that doctrine be worth the fundamental facts of which are not to be examined? To maintain that lifeless matter spontaneously assumes the living state, and not be able to give the faintest notion of what occurs when the change takes place, is not furthering investigation but sowing dogma. No one has any right to assert that the non-living can become living without the influence of the living, because at this present time such a change is against experience and is not conceivable. Marvellous, indeed, must be the change which occurs at the moment when the living imparts to the particles of the non-living its wonderful powers. Anyone who has seen living matter increasing, and moving, and dividing, will feel that it is useless to attempt to divine the nature of the change which takes place. How utterly impossible, therefore, must it be to conceive what may occur upon the hypothesis that the non-living becomes living without the intervention of any living matter whatever.

Fig. 15.

Masses of bioplasm and vegetable organisms (bacteria?) in active movement from surface of villus in cattle plague. The bacteria are only shown in outline. × 2800. pp 34, 66.

Fig. 16.



From central part of a dark red clot taken from aorta—cattle plague—within twenty-four hours after death. *a*, largest red blood corpuscles and those of average size; some were stellate. *b*, vegetable organisms, bacteria only shown in outline. *c*, white blood corpuscles, exhibiting active movements. × 700. pp. 34, 66.

Fig. 17.

Fig. 18.

Fig. 19.

Fig. 20.

Living organisms found in closed vessels into which fluid and organic matter had been previously introduced, due care having been taken to exclude air. The contents of the flasks had been well boiled. The large oval bodies in Figs 17, 18, are crystals. Fig. 17 × 1700, Fig. 18 × 1700, Fig. 19 × 1700 Fig. 20 shows one of the smallest objects in Fig. 19 × 2500. pp. 34, 49.

Fig. 21.

Vegetable growths in the mucus of the gall bladder. Cattle plague. These organisms were very numerous. Below *a*, a myeloid corpuscle. × 1800. The vegetable organisms only shown in outline. p. 66.

Fig. 22.

Fungi in different stages of growth in the sputum of a patient in the last stage of phthisis. Spores or germs are seen to be very numerous, and the stems have grown from these. × 215. p. 20

$\frac{1}{1000}$ of an inch ——— × 215 linear.

" " " ——————— × 700.

$\frac{1}{10000}$ " " ——— × 1800.

L. S. B., 1865.

[To face page ...]

The results of many experiments have, however, been brought forward in favour of the doctrine of heterogenesis. Organic matter, air, and water, which have been subjected to various operations supposed to effectually destroy any living particles that may be present, have been introduced into glass vessels which have afterwards been hermetically sealed. In spite of every precaution germs have made their appearance, and it has been inferred therefore that these sprang into existence without being in any way indebted to parental organisms.

In 1864–65 I examined with Dr. Child the contents of several hermetically sealed glass flasks, into which various vegetable infusions had been introduced. In order to prevent the entrance of germs from the air, and to destroy any germs which might exist in a living state in the matters introduced into the flasks, the following precautions were adopted by Dr. Child. ("Essays on Physiological Subjects," second edition, page 116.)

"In these experiments I have adopted some slight modifications of the apparatus used in the former ones. That now employed consists of a porcelain tube, the central part of which is fitted with roughly pounded porcelain; one end is connected with a gas-holder, and to the other the bulb is joined, which contains the substance to be experimented upon. The bulb has two narrow necks or tubes, each of which is drawn out before the experiment begins, so as to be easily sealed

by the lamp ; one neck is connected with the porcelain tube, as already stated, by means of an india-rubber cork, and the other is bent down and inserted into a vessel containing sulphuric acid. The central part of the porcelain tube is heated by means of a furnace, and when it has attained a vivid red heat the bulb is joined on the end of the porcelain tube, which projects from the furnace, being made thoroughly hot immediately before the cork is inserted, the cork itself being taken out of boiling water, and the neck of the bulb being also heated with a spirit lamp before it is inserted into the cork. A stream of air is now passed through the apparatus by means of the gas holder, and bubbles through the sulphuric acid at the other end. The substance in the bulb is then boiled for ten or fifteen minutes, the lamp withdrawn and the bulb allowed to cool while the stream of air is still passing through the porcelain tube, maintained during the whole time at a vivid red heat. When the bulb is quite cool the necks are sealed by means of a lamp. The advantage gained by means of this apparatus is that there is only one joint the perfection of which in any degree affects the success of the experiment, and of that joint it is easy to make sure. The porcelain tube also, being for a considerable part of its length fitted with small fragments of porcelain, all heated up to redness, easily insures that every particle of air admitted to the bulb shall be thoroughly heated."

In many instances undoubted organisms in a living state were identified, but the number present varied greatly in different flasks. The cause of the difference was not in all instances clear. In many cases the germs were so very minute, that I am quite sure they would have completely escaped observation if an object glass magnifying upwards of 1,000 diameters linear had not been employed. These observations necessarily lead us to conclude that the failure of observers who have worked with quarters and object glasses magnifying less than 500 diameters, is easily accounted for. Even Hallier, I believe, carried on his more recent observations with very low powers, and I believe the observations of both Pouchet and Pasteur are open to objections upon the same grounds.

Some of the organisms discovered in Dr. Child's infusions are represented in Figs. 17 to 20, plate III, from drawings made by myself. The large dumb-bell shaped bodies represented in Figs. 17, 18, are not organisms, but crystals. They could be readily distinguished from the living forms by their high refractive power, larger size, and absence of any movement.

It was supposed that boiling was fatal to all living things; then it was proved by experiment that some living things, under certain circumstances, did live in spite of being subjected to a temperature even above that of boiling water. But was it therefore necessary to assert authoritatively that no living

organisms could live at a temperature a certain number of degrees above that of boiling water, and that in cases in which any living forms are found in fluids in closed vessels that have been exposed to that temperature, they are formed *de novo?* What is there to prevent us from coming to the conclusion supported by so many positive general facts in nature which are well known, that the living forms discovered did spring from living matter which resisted the high temperature to which they had been exposed?

Moreover, in many of the experiments it does not appear that *every part* of the apparatus had been subjected to the high temperature. If the smallest portion were left above the bath in which the closed vessel was immersed, a few living germs might have escaped the destructive action, and from these might have been developed those which were subsequently detected and supposed to have arisen in a new way.

Dr. Charlton Bastian exposed fluids to a temperature varying from 148 deg. C. to 152 deg. C. (298·4 to 305·6 Fahrenheit) for four hours, and yet in the course of a few weeks living organisms were developed ("Times," April 13th, 1870). But even this striking fact proves nothing concerning the actual origin of the living forms, and it is more in accordance with the results of observation and experiment, to conclude that living forms might live though exposed under certain conditions to a temperature even of 350° Fahrenheit, than it would be to infer that the living

bodies present originated spontaneously in a fluid after it had been exposed to this high temperature. In every instance in which living forms have been attributed to spontaneous generation, the possibility of their origin from germs cannot be denied or disproved.

We have yet very much to learn concerning the influence both of high and low temperatures upon the minute particles of bioplasm constituting the germs of the lowest forms of life. And there is no doubt that the effect of the same degree of temperature would be different at different phases of the life of each species of fungus or low organism, and at different periods of the year. The effect would also vary according as the organisms were exposed to sudden great alterations of temperature, or submitted to intense cold or heat by slow and gradual changes; and even in man and the higher animals it is remarkable what great degrees of heat and cold can be borne if only the change be gradual. Some of the lower forms of life are habitually exposed to a temperature of 32, and would probably bear a very much lower temperature without being destroyed. These creatures, it must be remembered, are not merely *exposed* externally to this temperature like many vertebrata which have the power of developing heat within themselves, and whose temperature does not therefore vary with that of the surrounding medium, but they suffer every change which affects the medium in which they

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are placed, for their means of evolving internal heat are so slight and imperfect, that these may be left out of consideration altogether. Their bioplasm or living matter is adapted to live and grow at very low temperatures. Some organisms which do not grow and flourish at a temperature much below 50°, are nevertheless capable of bearing a low temperature, and may even live for a length of time imprisoned in solid ice. Whether the bioplasm of their organism is actually *frozen* is very doubtful. It is more likely that the bioplasm resists for a long time the process of congelation, and it seems to me probable that the motion which there is reason to think continues during life, prevents the living matter from freezing. Death most likely occurs before congelation takes place, but when once the living matter has actually become ice, its life is for ever destroyed, and it is incapable of being revivified or revitalized. It can never live or move again.

With regard to the power possessed by certain living organisms of resisting the destructive influence of a high temperature, it must be remarked that of certain of the forms discovered in the closed vessels (see p. 47), little is yet known. Many have been passed over by highly distinguished observers, and it is even probable that some have altogether escaped notice up to this very time. Of the very minute organisms in question, some may be able to resist the degree of heat to which they are exposed in the course of the experi-

ment without being killed—nay, there *may* be several forms of organisms extremely minute which are at present undiscovered, but which among other characteristics possess the remarkable property of resisting the destructive influence of a temperature of 300° or 350°. From these many might afterwards grow.

In many instances in which the absence of living germs would have been inferred, minute organisms, invisible by the aid of the magnifying powers usually employed, have been discovered, and in considerable number. And in some cases in which it has been stated that living organisms were not present, there is reason to think many might have been detected, had greater care in the examination been exercised, and higher magnifying powers employed. But though this be admitted, the fact does not in the slightest degree strengthen the case for the heterogenists. They have to prove that living forms appear under conditions which not only absolutely preclude the possibility of the entrance of living germs from without, but which ensure the death of every living form that may have been present in the substances used for experiment. The position is indeed a difficult one, for the more investigation advances, and the more we learn concerning the minute living germs which exist in such wonderful profusion, the more do we hesitate to place perfect confidence in the means employed for the destruction of those that were present before the experiment commenced, and for

excluding the entrance of living germs into the closed vessels in which the actual new generation of living organisms has been held to occur. Bearing in mind that living particles far more minute than could have been seen by the magnifying powers employed by Pasteur, Pouchet, and others, undoubtedly have been detected in the closed vessels, as in the observations of Dr. Child, for example, in which I had the advantage of assisting, and that germs are not invariably destroyed by boiling,—I would ask, is it not more reasonable to conclude that the living forms discovered were derived from pre-existing germs which obtained access to the fluids in consequence of the arrangements made to exclude them not being quite perfect, than that they had been formed anew from lifeless matter in the image of those very forms which have been unquestionably developed from predecessors like themselves? If the view of their formation *direct* from the non-living be accepted, how are we to account for their exact resemblance in form and actions to beings familiar to us, whose parentage is known; and for the fact that further growth and multiplication proceed precisely as those operations occur in germs derived from parental organisms?

But it has been suggested that although perfect living forms may not be developed spontaneously, perhaps a form from which these may soon be evolved, results in this manner. To argue from facts revealed in the course of observations made with magnifying powers

so moderate as a quarter or even an eighth (two to four hundred diameters) that *eggs* are produced spontaneously is surely, in the present state of knowledge, very hazardous, if not altogether unjustifiable. Of the supposed *lifeless* particles, by the aggregation of which the eggs are said to be formed, little can be learnt from observations with powers below a twelfth, because higher objectives would have resolved these supposed lifeless atoms into something very different, and perhaps have proved, that so far from being non-living particles, they were really living organisms which had been living for some time, and were at the time of observation at any rate far enough from the inorganic. Moreover, those who have advanced this theory, and those who have given in their adhesion to it, have not intimated how we may ascertain *when* the aggregation of lifeless particles assumes the living condition ; and they have left us completely in the dark as to *what* occurs when the marvellous change in question takes place. What a wonderful disturbance must occur at the instant of animation ! What a violent dislocation of elements which were combined as compounds, and what re-arrangement must take place when the inanimate collection of molecules starts into vitality ! What sort of force effects the change, and whence arises the destructive force and the constructive power ? Not a word of explanation on all this, and yet are we expected to accept as a fact proved, the formation of spontaneous eggs !

But the lifeless " proliferous disk," from which the living eggs are supposed to emanate so curiously, when carefully examined, is at once resolved into countless millions of separate living particles, every one of which lives and grows, and must be regarded as a distinct germ. Every one of these millions may give origin to successors, each little bioplast being a distinct being with all the attributes of an independent living organism, and containing within itself all the marvellous self-propagating powers of a living germ. I feel sure that anyone who patiently studies the simplest forms of life under the highest powers of the microscope, will utterly reject the so-called *observations* which are adduced in support of the formation of " spontaneous eggs " by the aggregation and coalescence of lifeless particles. In the ten thousandth part of such a proliferous mass are living germs enough to produce by simple division in the course of a few hours countless multitudes of living forms.

Living particles, far more minute than the life-constructing, non-living particles, have been seen and studied, and they have been observed to increase and multiply. But what is the nature of the mysterious operation of vivifaction which takes place at the moment of the conversion of the lifeless into living matter? Is the passage from the inanimate to the living condition sudden and abrupt, or gradual? According to Owen, this process is going on *daily* and *hourly*, so that there ought to be abundant opportuni-

ties for studying it carefully. This authority does not tell us what he means by the daily and hourly conversion of physical and chemical into vital modes of force, but surely such an investigator as Owen will not deem it right to leave this bare assertion without any further explanation. Every one interested in this wonderful problem naturally desires that he should give us some idea of the view he has formed in his own mind regarding what takes place at the moment when the mode of the force ceases to be physical and becomes vital—when the passive atoms become active organisms—when the inanimate leaves the state of lifeless rest and assumes that of living activity—when the matter acquires converting powers which it never possessed before—when, after having collected together by aggregation, the now living matter begins a new existence, and, instead of aggregating, its particles move away from one another—separate, never to join again. Any statements affirming that living particles have been *seen* to coalesce and join, under a power of less than five hundred diameters, are not to be relied on. A mistake is very easily made, and before an observation advanced in favour of such a statement can be accepted as true, it must receive confirmation; not only on account of the errors possibly made by the observer himself, but because the conclusion is opposed to many broad facts which have been demonstated and accepted, and particularly the fact of the formation of these same

organisms by division and subdivision, which has been observed and confirmed in many cases by hundreds of competent observers. Nothing is gained by the statement being repeated over and over again that lifeless particles of matter come together and form a living thing, save that by mere iteration people who have concerned themselves little with the subject may be persuaded to assent to the view advocated. But knowledge cannot be advanced by declarations and affirmations, or by the consent of numbers.

Very recently this question of *spontaneous generation* has been re-opened in this country, by Dr. Bastian, whose papers will be found in "Nature," for June 30th, July 7th and 14th, 1870. New experiments have been made, and the author comes forward as a warm advocate of the doctrine of Heterogenesis. He commences, however, by adducing *arguments* in favour of the view which he seeks to establish. These arguments are founded upon evidence which we possessed before he commenced his experiments. He endeavours in the first instance to convince the reader that probabilities are strongly in favour of heterogenesis, in order to prepare him for the acceptance of the conclusions he has himself deduced from his experiments.

But it is obvious that if already existing evidence were really as decisive in favour of the doctrine as the reader is led to suppose it to be, new experiments were unnecessary and superfluous, while if, on the

other hand, these new experiments were as conclusive as Dr. Bastian maintains, *à priori* arguments could not make them more true, or in any way promote their acceptance. If new experiments were really needed, and no one doubts this, it would have been better to have allowed them to rest upon their own merits, and speak for themselves.

Some of the experimental results are at variance with those arrived by previous investigators, and are very remarkable. It would not therefore be right to offer an opinion upon them until the same experiments have been carefully repeated. But it is not possible to resist drawing this general inference from the drawings and statements published in the latter part of Dr. Bastian's memoir, viz., that a solution of tartrate of ammonia and phosphate of soda boiled for twenty minutes and kept *in vacuo*, for from ten to thirty days, is really as potent, or even more potent, as a generator of life than many solutions of vegetable matter which have been exposed for several days to the atmosphere! Indeed, several of Dr. Bastian's experiments appear to me to prove too much, and until they have been repeated and similar results obtained by other observers, he must excuse me for postponing for the present the acceptance of the statement that such organisms as he has figured in Figs. 12, 13, 14, 15, and 17, have really been developed as he supposes.

Unquestionably, if Dr. Bastian's observations should prove unassailable, the new facts he has discovered will be regarded as of the very highest importance;

indeed they would go far towards modifying the opinions expressed by myself and many others upon the subject of heterogenesis. His statements about the genesis of crystals, and other arguments, founded upon old evidence, however ingenious, seem to me worthless, and only weaken the cause the heterogenists have at heart, because the analogies supposed to exist are fanciful, and do not really obtain.

But while the evidence in favour of the origin of organisms *de novo* remains inconclusive, uncertain, and open to objection, there is no doubt whatever concerning the origin of living beings from pre-existing living beings. Many microscopists have actually seen the living particles detach themselves from a pre-existing living mass, and there is abundant evidence to prove that this process takes place among creatures occupying various positions in the scale of living beings, as well as in the different forms of bioplasm from the highest organisms. In some of the the lower creatures the process may be watched from hour to hour, as it gradually progresses towards solution of continuity, and the formation of two beings out of one is completed. I have myself frequently witnessed the sub-division of living particles from the organisms of the highest as well as from those of the lower forms of life, so minute and of such tenuity, that they could only be seen with difficulty when magnified 5,000 diameters; and there is much reason to think that even if the magnifying power could be increased to 50,000 diameters, there would still be

seen only more minute living particles growing and dividing and giving rise to particles like themselves.

Are we to believe, then, on the mere dictum of authority, that living germs are formed in two ways— upon two distinct principles? 1. By being detached from parent living matter; and 2. By the direct combination of lifeless particles without the intervention of any pre-existing living matter at all?

It must be freely conceded that many facts are susceptible of more than one interpretation, and may be regarded as being of different import by different minds. Nay, in some instances, the very same facts have been appealed to, and not in any way unfairly, in support of opposite and conflicting doctrines. With reference to the question of spontaneous generation, I must, however, venture to remark, that to my mind the case of those who at this time hold to the doctrine of the direct origin of living beings from non-living matter appears so hopelessly opposed to facts, that I should as soon think of believing in the direct formation from lifeless matter of an oak, a butterfly, a mouse, nay, man himself, as in that of an amœba or a bacterium.

After so many failures to force people to believe that the phenomena peculiar to living beings are to be explained by physics alone, it was natural to expect that the language employed by those who still entertain such doctrines would have become more guarded, if not more exact. But, on the con-

trary, the more conclusively it is proved that the physical facts yet discovered are incompetent to explain vital phenomena, the more do we find vague but most positive assertion used, as if this were as convincing as the results of observation and experiment. The more desperate the case becomes the more violently do its advocates affirm that their cause is good ; the more strongly do they assert they are in the right. And yet those who are determined to support the physical theory of life need not care if facts and arguments are against them, for, in order to prove their case to the satisfaction of many persons they have but to exclaim triumphantly, " In the years yet to come new facts shall be discovered which will demonstrate conclusively the truth of the physical theory of life ! "

Since cosmic vapour has produced worlds, shall not air generate life ? Was not the announcement made at the Royal Institution some years ago that the sun formed the heart and built the brain, and that cattle, and verdure, and lilies, were his workmanship ? Why, then, shall not the air divide with the sun these marvellous powers ? May we not be indebted to the sun for the formation of complex organs like the heart and brain, and may not the air generate that much simpler moving jelly-like matter of which the simpler beings are composed ?

In conclusion, the following suggestions shall be offered as an unworthy contribution towards esta-

blishing an hypothesis which may illumine the path of the physicist until he arrives at the demonstration of the physical origin of life. Since it is well known that the infinitely minute particles of cosmic vapour, of which by mere aggregation worlds are formed, are diffused through space, is it not reasonable to imagine that between these, perhaps supporting them as well as separating them, is a subtle animated vapour? Heat, as is well known, causes a re-arrangement of material particles, which may be scattered or condensed according as the cosmic forces operate upon them. This scattering or condensation would occur at a different temperature in the case of different particles, according of course to the original properties of the molecules. Certain particles of the cosmic vital steam, would, at a given temperature, gyrate upwards and distribute themselves, while others *might* approach one another and form a vital crystal. This, growing by aggregation, *might* become a spontaneous ovum, the product of evolution and formifaction, containing potentially not only a fully developed organism, but whole generations of altering forms, every one of whose specific characters *might* be defined at this very time by a sufficient intelligence! The rapid increase of physical energy encourages the physicist in his attempts to forecast the future, while it enables him to secure some fragments of the real which, but for his successful efforts, would have been for ever lost in the infinite void of unfathomable nothingness.

SUPPOSED INFLUENCE OF VEGETABLE GERMS IN CAUSING DISEASE.

The manner in which they might enter the Body.—No wonder that many of the diseases of man should be attributed to microscopic fungus germs so very small that they could readily enter his organism by any of the numerous pores all over his body. Particles so minute could easily pass into his blood through the soft mucous covering of his mouth or stomach, entering these recesses with food and water. They would not insinuate themselves into the chinks between the epithelial cells of his cuticle and *move* towards the blood, as is possible in the case of bodies which possess the power of active movement, like an amœba, or a white blood corpuscle, or a pus corpuscle, but they would extend inwards, by growth and free multiplication in the very substance of the protecting epithelium. Each new particle produced would thus get nearer and nearer to the blood, which would at last be reached by the growth of particle after particle in advance. Becoming immersed in a medium adapted for their nutrition, the germs which had gained access to the blood would grow and multiply very rapidly. Countless myriads of such germs might circulate to all parts of the body. Multitudes of these becoming stationary in the capillary vessels of the cutaneous and mucous surfaces would increase

there, and might give rise to the morbid phenomena which characterise fever.

Since it has been shown that living germs of entozoa a thousand times larger than these vegetable germs may traverse man's textures, and pass long distances through the tissues and organs of his body, until the particular locality suitable for their development into a higher stage of being has been reached, it is impossible to oppose to this notion of the entrance of vegetable fungus germs any serious objection, at least from this point of view. But at the same time, before anyone who is acquainted with the facts, and reflects carefully, will accept this doctrine, he will desire to be satisfied upon many points which unquestionably require elucidation. It is not sufficient to show that such particles *might* enter the body in the *manner* suggested. But it is necessary to prove not only that they really do enter, but that they give rise to the changes in the way which is suggested by the theory in question. If the vegetable germs which have been referred to are indeed the active agents, we ought to be able to demonstrate them, for there is no difficulty whatever in demonstrating closely allied organisms where they do exist, as for instance in the epithelial cells on the mucous lining of the mouth, in which millions can be seen at any time.

Of the Vegetable Germs actually discovered in the fluids and tissues of the higher Animals during Life.— In every part of the body of man and the higher

animals, and probably from the earliest age, and in all stages of health, vegetable germs do exist. These germs are in a dormant or quiescent state, but may become active and undergo development during life should the conditions favourable to their increase be manifested. Indeed, if the flow of fluid which persists in the normal state in the ultimate parts of the tissues as long as life lasts be stopped, changes take place exactly resembling those which are occasioned in dead tissues removed from the body, and kept at a temperature of 100 degrees. As has been remarked, "decomposition" takes place, and, if this decomposition is not a consequence of the multiplication of the vegetable organisms, it is at any rate certain that the growth and multiplication of these bodies are constantly associated with the change in question. There cannot be a doubt that vegetable germs exist in the internal parts of the body which would grow under the circumstances supposed.

The higher life is, I think, everywhere interpenetrated as it were by the lowest life. Probably there is not a tissue in which these germs do not exist, nor is the blood of man free from them. They are found not only in the interstices of tissues, but they invade the elementary parts themselves. Multitudes infest the old epithelial cells of many of the internal surfaces, and grow and flourish in the very substance of the formed material of the cell itself. But the living germinal matter of the tissues and organs is probably

perfectly free from vegetable germs. Some are, however, not uncommonly met with on the free surface of the germinal matter, where its death and conversion into formed material are taking place. So long as the higher living matter lives and grows, the vegetable germs are passive and dormant, but when changes occur and the normal condition departs, they become active and multiply. Millions are always present on the dorsum of the tongue and in the alimentary canal, but they remain in what may be termed a germ or embryonic state. The normal secretions poured into the alimentary canal prevent their growth, and the nourishment comes to us instead of being appropriated by them. But what happens if some of these fluids be suppressed or changed in quality? The bacteria grow and multiply, and the nourishment is no longer absorbed into our bodies. In infants a little derangement in digestion will entirely prevent the assimilation of the milk, which remains in the intestines a source of irritation, until it is expelled, serving only for the nutrition of bacteria, which are found in countless multitudes in every particle of it. If more milk be introduced it soon undergoes the same change, and the child might, perhaps, be starved by the persistent introduction of fresh food. If food is withheld for a time, the alimentary canal soon becomes emptied of its contents, and regains its natural healthy action, a process which is expedited, as is well known, by the administration of

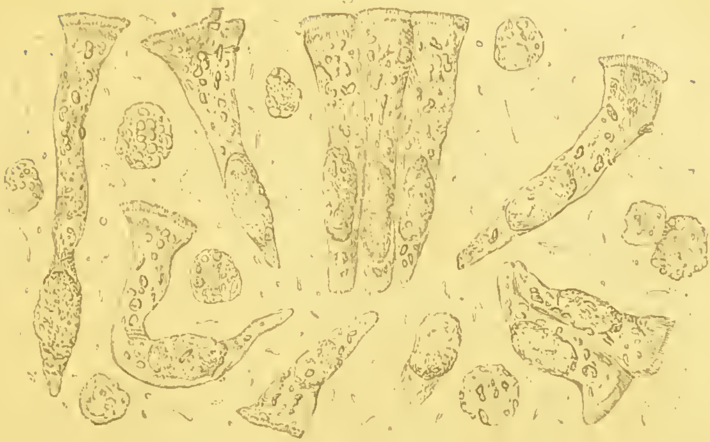
some simple purgative, which excites the glands to pour out secretion, and so the passage is cleared from the stomach downwards.

In many very different forms of disease these germs of bacteria, and probably of many fungi, are to be discovered in the fluids of the body, but the evidence yet adduced does not establish any connection between the germs and the morbid process. In Plate IV. these minute organisms are represented in the contents of the alimentary canal, and in the interior of the epithelial cells of the mucous membrane of the intestine in cholera. In the contents of the blood-vessels of the same disease, and in the blood taken almost immediately after death from the vessels of animals destroyed by cattle plague and other fevers, similar bodies have been found, Plate III, figs. 15, 16, 21, though probably not of exactly the same kind in every case, Figs. 25, 26, 27.

As has been already stated, germs apparently of the same nature as those figured in Figs. 23 and 24 from cholera, are invariably to be found in the old epithelial cells of the mouth of healthy persons, and not rarely in those from many other surfaces. In the intestinal contents in various slight derangements, they are common enough, so that we cannot but conclude that their presence is due rather to alterations in the fluids *consequent upon* morbid changes, than that they are themselves the cause of the disease. They follow the morbid change instead of preceding it.

GERMS.—BACTERIA IN INTERIOR OF THE BODY.

Fig. 23.



[illegible]nar epithelium from the jejunum of a child who died of cholera. The small bodies in every part of the field and many of those in the epithelial cells themselves are bacteria and bacteria germs. These are not peculiar to cholera. They were alive when the specimen was examined. × 700. p. 68

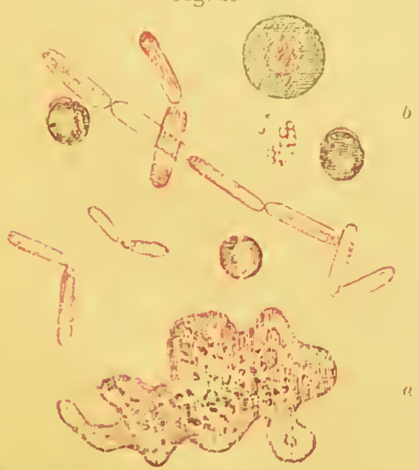
Fig. 24.

Summit of one of the epithelial cells represented in [illegible] 23, containing germs in the interior. *a*, thick summit [illegible] the cell. *b*, free bacteria germs. × 1800. p. 68

Fig. 25.

[illegible]structed vessel, with bulgings, from the summit of a villus. Case 3. Cholera. In the interior were bacteria, oil globules, blood corpuscles, and the sporules of fungi. × 700. p. 68.

Fig. 26



[illegible] in the [illegible] of a cow when [illegible]. The round bodies *b* are growing [illegible] corpuscles still containing bioplasm. The [illegible] *a* is a white blood corpuscle. The blood was quite warm when examined. × 2800. p. 68

Fig. 27.

A very small portion of one of the contracted and altered capillaries from the summit of a villus. Cholera. × 2800. *a* is a small particle which somewhat resembled a sporule of a fungus. *bb*, minute particles of very smooth material (growing bioplasm). Oil globules are also seen in considerable numbers. p. 68.

$\frac{1}{1000}$ of an inch ———— × 700.
$\frac{1}{10000}$ " " —— × 1800.
" " " —— × 2800.

And the same observations may be made with regard to the presence of bacteria in the blood of man and animals destroyed by various diseases.

Sometimes these germs grow and multiply in a secretion not perfectly healthy, before it has left the gland follicles, and they have been detected in the milk as it issued from the breast, in the saliva, in the bile and urine, as well as in other secretions. It will no doubt be said in all these cases, "the germs have been introduced from without—they pass from the air into the orifice of the duct, and thus make their way to the gland. From this point they might readily pass into the blood." But it is more likely they are in the blood and in the tissues at all times. They are met with in the blood especially, in some instances in which there is no reason whatever for concluding they made their way into this fluid shortly before they were found. Nay, little particles may be seen in the circulating fluid which I believe to be these lowly germs, ready to grow and multiply whenever the conditions become favourable. I have seen such particles adhering to the surface of the white blood corpuscles, and also to the red blood corpuscles. In the fibrin of an aneurismal clot I have found active bacteria in vast numbers, and have observed the erosion resulting from their long-continued action so very short a time after death, that I feel quite certain they had been living upon the coagulated fibrin, and growing and multiplying during several weeks previously, and yet they had not passed.

into the general mass of the blood. But if this had accidentally happened, they would have been destroyed instead of multiplying, if the blood was in a healthy state. In cases in which these organisms have been discovered actively multiplying in the blood, that fluid must have already undergone serious changes, which had rendered it unfit for the nutrition of the body.

I cannot agree with those who consider that we have evidence in favour of the view that the bacteria are really the active agents in cases in which the blood has been shown to exhibit the properties of a *specific contagious virus*. The disease called *malignant pustule* has been attributed by Davaine (Comptes Rendus, 1864) to the presence of bacteria in the blood, but this observer does not prove that the bacteria were the poisonous agents, and many circumstances render it probable that other matters suspended in the blood constituted the real virus, while the vegetable organisms were but harmless concomitants. Polli, Tigri, and many others, have attributed typhoid fever and allied diseases to bacteria in the blood acting after the manner of ferments, but the objections raised to the fermentation theory have not yet been disposed of by those who advocate this doctrine. Indeed, many authorities who have attributed various phenomena to fermentation, and have spoken of the fermentation theory, have not explained what they mean by the terms they employ, and appear to have very vague notions concerning the

nature of the process called "fermentation." This word is often employed very carelessly, and like "irritation," "nutritive irritability," "stimulus," and a number of other terms, is supposed to account for many phenomena, although its meaning has not been defined, and those who use it do not tell us what they mean by it.

It appears then that bacteria germs grow and multiply whenever a change takes place in the solids and fluids of the organism which develops compounds suitable for the pabulum of these living bodies. From the fact that bacteria grow and multiply not only in a few special fevers, but in a great variety of different morbid conditions, it is evident they have nothing to do with any particular form of disease. All attempts to demonstrate various constant species of bacteria, representing different contagious diseases—and many attempts have been made—have completely failed. There is greater difficulty than would appear at first in testing the matter experimentally, for it is probably impossible to introduce bacteria in quantity into the blood of a healthy animal without introducing at the same time putrescent matters which by themselves would occasion the most serious derangement. Active bacteria introduced into a healthy wound or amongst the living matter of healthy tissues, will die, although the most minute germs present, which escape death, may remain embedded in the tissue in a perfectly quiescent state.

Before the bacteria can grow and multiply, the death of the higher germinal matter must occur; as long as this lives, it, and the adjacent tissues, are freely permeated by healthy fluids, and will efficiently resist their assaults. Much as I admire the interesting observations of Mr. Lister, and firmly as I believe the facts as stated by him, I venture to doubt if the efficacy of the treatment he so ably advocates is due to the prevention of the entrance from without of these germs. There are germs out of number *within*, which would grow and multiply in the wound, however perfectly those outside were excluded, provided only the wound itself were in a state favourable to the process. Bacteria germs appear in close cavities in the substance of tissues during life and within the blood-vessels, as has been already stated. The true explanation of the undoubtedly beneficial action of the carbolic acid antiseptic treatment may be very different to the explanation offered by Mr. Lister. To me it appears much more probable that the carbolic acid acts directly upon the growth and multiplication of the bioplasm of the part; but this question shall be considered in another part of this memoir, after the mode of formation of pus has been referred to.

The virulent poison which sometimes produces such terrible results upon the healthy (?) organism in cases of dissection wounds cannot be attributed to the presence of vegetable germs, for the period of its most virulent activity is very soon after death, but before

the occurrence of putrefaction and the development of bacteria.

It has been assumed that the poison in question is not developed until after death has occurred. But no one has shown that if inoculation were effected while the patient yet lived, the results would be in any way different. There is, I think, no more doubt that such poison is developed during life than that the poison of small-pox, syphilis, and many other poisons which are allied to these, and probably grow and multiply in the same manner, increase during life.

When putrefaction has actually set in, and bacteria germs are being developed in immense numbers, a punctured wound is not productive of the dire consequences which too often result if inoculation takes place within a few hours after death. In fact, the real virus loses its power when decomposition commences. Before vegetable germs appear the virus is active ; soon after these have been developed it is harmless. Its power cannot, therefore, be attributed to the germs but must be due to something else which continues to live and remains active for a short time after death, and then for ever disappears. The nature, mode of origin, and multiplication of this active material will be fully discussed in the second part of this work.

Question of derivation of Fungus Germs from higher Germinal Matter of another kind.—As has been already remarked, lowly vegetable germs appear in closed cavities in the substance of dead animal

and vegetable tissues. I have often seen them within vegetable cells in which not a pore could be discovered when the tissue was examined by the highest powers. I have detected them in the interior of the cells in the tissues of animals, and in the very centre of cells with walls so thick and strong that it seems almost impossible that such soft bodies could have made their way through from the surrounding medium. How are we to account for the presence of living particles in such situations? I have no doubt that ere long the theory will be advanced that the living matter of the cell, and the formed material of which it is composed, become changed, and assume the condition of bioplasm of a lower grade of organisation. Thus, it will be said, from one form of living matter a lower and more degraded form is evolved, the lowly germs springing from the living matter of the cell itself. And it might be alleged that the same forces which were once active in the cell, become active in the new organisms which grow and multiply after it has ceased to live.

Such simple germs are, as has already been stated, from time to time found in the blood of man, and to them various disturbances, ending in death, have been attributed. They have been looked upon as the germs concerned in the production of disease and in the destruction of life much higher than their own; but the matter on which they live has ceased to take part in the actions of the higher life, and instead of being decomposed into noxious

gases inimical to all life, it becomes appropriated by the vegetable organisms, which grow and multiply enormously. But these having continued to increase, at length cease to multiply, and in their turn die. The products resulting from their death may serve as food for beings a little higher in the scale.

But we have now to enquire, how, if they are not actually formed there, these bacterium germs get into the interior of a perfectly closed cell. There is no real difficulty in accounting for the entrance of these germs through the cell wall; for although no pores may be visible even with the aid of the highest powers, still pores sufficiently large to permit the passage of such very minute particles as the germs are, necessarily may exist, if not in the fully-formed state of the cell, at least at an early period of its development. If we examine, under the highest powers of the microscope, fluid exudation which we know may pass through membrane, and which, when examined by ordinary means, appears perfectly clear, like water, we frequently find in it minute particles of living matter. By the $\frac{1}{50}$ the apparently clear fluid rotating round the cells of vallisneria is resolved into multitudes of extremely minute particles of colourless matter, or bioplasm, every one of which possesses the power of moving, and is alive. There is, then, nothing improbable in the supposition that minute germs might pass through the cell wall with the pabulum. They would remain in the cell wall or tissue perfectly

inactive and dormant as long as the cell remained vigorous and healthy, but sooner or later, if not from disease, from old age, changes must occur by which a state of things results which is favourable to the germs whose turn invariably comes at last. These grow and multiply and live upon the dead germinal matter and the altered and softened formed material of the cells. We must, in the absence of positive demonstration, hesitate to accept the doctrine that the lowest organisms may result from degradation of the living matter, which at one time formed a part of a higher being. But we may *refuse* to accept the statements which have been made as to the direct conversion of the fibrillæ or discs of striped muscle into bacteria, because such assertions are contradicted by well-known facts. From the red blood corpuscles may be made bodies which might be mistaken for bacteria; nay, if the most practised observer were to examine one of these bodies only by itself, he might easily be deceived. The little beaded filaments exhibit movements which, though differing from the movements of the bacteria, would certainly be mistaken for them by an unpractised observer. But it ought not to be necessary to state, that in microscopical research mere resemblance in external form and general characters should not be accepted as proof of identity of nature any more than in ordinary observation.

Of Diseases known to be due to Vegetable Organisms.—The diseases of man and the higher animals, known

to depend upon the growth and development of vegetable organisms, are local affections confined to a part of the body not involving the blood, while for the most part, the different forms of contagious fevers are general affections in which the whole mass of the blood, and, in some cases, every part of the body, is affected, and is capable of communicating the disease. In fungus diseases, the structure of the vegetable organism can be made out without difficulty, and the vegetable examined in every stage of its development. The microscopic characters are distinct and definite enough. No such success attends our efforts to prove that vegetable organisms are truly the active agents in contagious fevers. And in many of the diseases which are at this time considered to be actually due to the multiplication of vegetable germs, it is doubtful if the tissues and organs invaded were perfectly healthy at the time of invasion. For all persons exposed are not attacked, and if not in all, at least in the great majority of instances known, the view that a morbid change must occur before the tissue is in a state to be invaded by the fungus growth, is tenable. In fact, it has been already shown that the fungi which commonly grow on the surface, and in other parts of the body, do not *produce disease.* The germs of fungi may remain perfectly passive and quiescent in healthy textures, growing and multiplying only in those which have already deteriorated in consequence of disease or old age. The growth of

the vegetable germs, therefore, instead of occasioning the disease, may be dependent upon the occurrence of phenomena altogether different. There are, I think, very few morbid conditions that are unquestionably solely due to the growth and multiplication of vegetable fungi.

Some difficulties which prevent us from accepting the Vegetable Germ Theory of Disease.—If contagious diseases are due to the entrance into the organism of such minute vegetable germs as those described, is it not wonderful that any one escapes disease? Multitudes of germs of different species, as numerous as are the contagious diseases from which we suffer, must, if this theory be true, surround us. And yet the fungus germs, which are to be detected easily enough, and which indeed do exist in great numbers, are not known to cause any disease. Still, upon this view these must be the disease-producing particles, for they are the only vegetable germs that have been discovered. Passing into our lungs with every inspiration, entering our stomachs with our food and drink, everywhere in contact with our cuticle, in the chinks of which they might grow and multiply, these fungus germs must, one would think, pass in vast numbers into our blood, and be carried to every part of our bodies. Contagious diseases ought, therefore, to be more common than they are, and escape from attack should be almost impossible.

Vegetable fungus germs are to be met with in every

country, and there are probably few substances in or upon the earth which are entirely free from them. If their introduction alone is sufficient to produce disease, one malady ought to follow another, until the catalogue of contagious diseases becomes exhausted, or the organism is destroyed. But many fungi even form articles of diet and medicine, and many animals devour whole forests of living, growing fungi in every mouthful of food they take. Of these not a few are destroyed by the fluids poured into the alimentary canal, digested, and the products appropriated by the organism. The animal, in fact, lives upon them, instead of the fungi living upon him ; and in various cases in which certain fungi do actually invade our tissues, the evidence of change in these last having occurred prior to the development of the fungi, is sometimes so distinct, that the conclusion is irresistible, that, so far from the fungus attacking a healthy structure and damaging it, the structure itself had deteriorated and changed, or had undergone morbid derangement ere it was invaded. By decay it would appear that it had become converted into material adapted for the nutrition of the fungi, the growth of which had been effectually resisted as long as the tissue remained healthy. If this be so, the fungi cannot be regarded as the *cause* of the disease, any more than the vultures which devour the carcase of a dead man can be looked upon as the cause of his death.

Vegetable germs exist in countless multitudes

where contagious diseases are unknown, as well as where they are rife. Their sparing or abundant multiplication varies with altering temperature, moisture, and other conditions, and does not always coincide with the fluctuation of disease. If vegetable germs are the seeds of disease, the seeds are everywhere, while in many instances the diseases are remarkable for being particularly local. If these be disease germs, they are present in all climes, while the diseases themselves are limited to certain definite regions. We may cultivate the vegetable germs without producing disease, and disease may be raging while there is no evidence of a corresponding increase of the vegetable organisms upon which it is supposed to depend. If vegetable organisms are really the contagious particles, it is hopeless to attempt to protect ourselves from their invasion, and to talk of extirpating them would be absurd, for were a particular species destroyed over half England to-morrow, the next breath of wind would bring multitudes of germs to take the place of those which had been swept away. Nor should we stand any chance of escaping their ravages, by leaving our dwellings in cities, and taking up our abode in the country, or by taking refuge even in the highest mountains, or other sequestered places far away from the haunts of men. And if fungi are developed spontaneously, and disease germs consist of fungi, the state of things is still worse, as in that case, if eradication were possible, it would be idle to attempt to

effect it ; for if all in existence at any one time were utterly destroyed, new ones would soon spontaneously emanate from the non-living, and we should be in as bad a plight as before. Minute vegetable germs, resembling those to which contagious disease has been attributed, are everywhere, though they may easily escape observation. If, however, the pabulum adapted for them be present, and the conditions favourable to their development exist, they soon grow and multiply, and abundant evidence is afforded of their presence.

In answer to the observation, that if these fungus germs constitute the morbid material of contagious diseases everyone should be attacked, it might be said, "the organism is not always in a state favourable for invasion, and that it is only in exceptional cases, or in exceptional states of health, that the presence of fungi affects us deleteriously." To this the reply might be, that "there are many kinds of contagious matter which give rise to characteristic effects with unerring certainty." The introduction of as much as would adhere to a needle point into the body of a healthy subject, acting without a chance of failure. If, therefore, we accept this vegetable germ theory of disease, we must hold that there are certain fungi which affect all men in all conditions of health, but which are at present undiscoverable, while other fungi, which are very easily discovered, are not known to affect the organism in any condition of health ;

and that yet other fungi, also unknown at this time, exist, which are only able to produce their effects in organisms changed by certain previous actions for their reception,—and this, in spite of the fact that no connection whatever has been shown to obtain between any contagious disease and any kind of fungus.

But yet in favour of such a doctrine it might be urged with truth, that some *parasitic organisms* affect all indiscriminately, while others require certain preliminary changes to be carried out before the various parts of the organism they delight in are adapted for their habitation and are rendered favourable to their increase. It must not, however, be forgotten that parasites which are known exhibit at one or other stage of existence certain well-marked characters by which they may be recognised with the utmost certainty, and this is especially the case with parasitic vegetable organisms, many of which can be grown artificially without much difficulty, and studied in the several different stages of their development.

Those who look with partiality upon the vegetable germ theory of disease should consider how the absence of any bodies like vegetable fungi in animal fluids and solids, proved by experiment to possess active infectious properties, is to be accounted for. Not only is it the case that vegetable organisms are not to be found in the perfectly fresh virus when it is most active, but no specific form of vegetable growth can be developed from the particles which do exist, as would almost

certainly be the case if the particles present in the fluids had been vegetable germs. Every kind of parasitic germ known is capable of undergoing development into a body having definite and well-marked characters. Though in the germ stage different species would resemble one another, as indeed is the case as regards creatures much higher in the scale, they do not constantly retain indefinite characters. And when the germs are so minute as to be readily passed over in ordinary microscopical examination (100 to 300), by the aid of higher powers excessively minute vegetable germs may be recognised with certainty, if not by their form, at least by their mode of multiplication. The germs of many animal parasites are also to be distinguished by careful examination, and from what we know of the life history of these, we should not be justified in attributing contagious diseases, in which every drop of animal fluid in the body possesses contagious properties, but for a fixed and definite period of time only, to germs of a new class of animal or vegetable parasite of which not one species has been discovered, and the germs of which are even less than $\frac{1}{100000}$ of an inch in diameter. It may, therefore, be affirmed that the matter which forms the active virus or poisonous material does not exhibit the properties of any vegetable or animal parasitic organism yet discovered and identified. Neither can any organisms, having special and peculiar characters, be developed from any definite virus.

Will, then, the advocates of the vegetable germ theory of disease maintain that this view ought to be accepted simply because, in some of the discharges and fluids of diseased animals or man, vegetable germs are to be found, in face of the fact that similar germs are to be detected in all sorts of *harmless animal fluids and even in foods which are taken and digested?* As soon as fungi have developed themselves freely in animal fluids possessing special contagious properties, such as vaccine lymph, or smallpox lymph, the specific characters of the poison become weak or disappear. This seems to negative the view under consideration. In answer it might be urged that, "because a few vegetable organisms excite the disease, it does not therefore follow that a multitude should be more potent,—rather the contrary; for a few might retain their vitality and propagate themselves, while, if a great number were present, the pabulum necessary for their activity would be insufficient, and all would perish!" The advocates of the theory may be permitted to enjoy any advantage that can be derived from this sort of argument; for, however cleverly it may be put forward, most people who know the facts of the case will be of opinion that the vegetable organisms when present are but accidental concomitants, and that a potent poison, not of the nature of a vegetable germ, is present in the animal fluid or solid in which the contagious properties are known to reside.

PART II.

DISEASE GERMS:

THEIR

REAL NATURE.

AMONG the most fatal diseases from which man and the higher animals suffer are those which are called *contagious* or *infectious*. These depend upon a poison, which, having entered the body, grows and multiplies there in a marvellous manner peculiar to matter which is alive. The living poison may be introduced into our bodies in the air we breathe, in the water we drink, or in the food we eat, and may possibly also gain access to us by the pores of the skin, or even by penetrating through the cuticle itself. No care on our part will insure us against invasion; but, though surrounded by infection, and living among contagious disease germs, it is by no means certain that we shall be attacked, indeed the probabilities of escape are very great. We might wear water-proof coats and water-tight boots, cover the head with mackintosh, protect the nostrils and mouth with a cotton wool respirator, and grease or varnish every particle of skin exposed, and, in spite of

all these precautions, the living germs might enter our bodies, grow and multiply there to our detriment, and perhaps destroy us; while a friend who took no such pains to protect himself, and may have been for hours exposed to the infected air, might escape altogether, and enjoy perfect health though surrounded by contagion on every side!

We shall have to consider in another part of this work what circumstances probably increase our liability to attack, and by what means we may improve our chance of escape.

The diseases in question are known as *Zymotic* (*Ζύμη*, a ferment, leaven), but under this head have been also included affections due to malaria, maladies resulting from changes in the food, and diseases depending upon the introduction into the body of living parasitic animal or vegetable organisms. This classification is not altogether satisfactory, because diseases induced by the introduction into the organism of bodies so essentially distinct from one another, as for instance the poison of small-pox, and the tape worm, should scarcely be included in one class. At the same time, when the subject comes to be carefully considered, it must be admitted that there are many difficulties, while the classification in question possesses many practical advantages, and upon the whole has been found to work well. If the conclusions arrived at in this work are accepted, it will not be difficult to separate the fevers and allied diseases from others which are at present

grouped together in the zymotic class, without introducing changes in nomenclature or classification, which might cause inconvenience in practice.

Some of the contagious fevers are among the most terribly fatal maladies which we are called upon to treat, but many of us feel convinced that these of all diseases are the most preventible, for this has been clearly proved by the great success which has already attended measures as yet but imperfectly carried out. Yet year after year, in consequence probably of those who make our laws being ignorant of the facts, and seldom brought face to face with actual cases of disease, little is done to reduce the virulence, or to arrest the spread of these frightful scourges, some of which, as scarlet fever, are almost as fatal to the children of persons in easy circumstances as they are to the children of the classes whose day's work seldom produces much more than is sufficient for the day's sustenance, and sometimes less than enough to preserve the body in a state fit for work.

The ignorance even of many very intelligent persons concerning the simplest practical requirements for limiting the spread of contagious diseases is deplorable, so that in epidemics the scourge is sometimes fostered and spread by the very persons in charge of the sick, sometimes by the patients being allowed to mix with the healthy and distribute far and wide the germs of disease. Heads of families are not always aware that a child who has completely recovered from scarlet

fever and is in fact well, may communicate it to half the children with whom he comes in contact, unless he is placed in quarantine for two months, by which time there is reason to think all the active contagious particles will have died, or will have been removed.

From a return moved for by Mr. W. H. Smith, and printed by order of the House of Commons, we learn that the deaths from *zymotic diseases* in England and Wales amount to upwards of 111,000 annually, out of a population of under 22,000,000, the total deaths from all causes being under 500,000. Continued fever destroys upwards of 20,000 lives per annum; scarlet fever alone averages about 18,000 victims, and sometimes destroys 30,000 persons in a single year. The actual numbers are given in the accompanying table, which has been calculated from the Registrar General's return above referred to.

	Fve years, 1864 to 1868, inclusive.	Average for one year.
Estimated population	,,	21,210,431
Total deaths	2,438,826	487,765
Diarrhœa and Cholera	125,828	25,165
Fever	100,807	20,161
Scarlet fever	93,297	18,659
Hooping eough	54,077	10,815
Measles	46,043	9,208
Small-pox	21,689	4,337
Diphtheria	18,222	3,644
Other zymotie diseases	97,127	19,425
Total Zymotie diseases	557,090	111,418

Being 22·84 per cent. of the total deaths.

It would be too much to say that this frightful mortality represents the deaths from preventible diseases, but there can be little doubt that good sanitary regulations, combined with cleanliness and temperance upon the part of the people, would save at least 100,000 lives annually in England and Wales alone. But this eminently practical part of the subject has been well considered by others far better qualified for the task than myself. I therefore pass on to discuss the nature of the material concerned in the spread of contagious diseases. It was shown in the first part of this work that the active substance was not a lowly vegetable organism developed independently of man or the animals subject to disease. We have, therefore, now to enquire what is the material substance which passes from the diseased to the healthy organism in small-pox, in measles, in scarlet fever, and other allied contagious diseases from which man and domestic animals suffer so severely. The material in question grows and multiplies and produces its kind as all living things do, and as nothing that does not live has been proved to be capable of doing. We may therefore conclude that it is living matter. But it has been already shown that it is not a vegetable organism. What then is its nature? The arguments advanced against a vegetable germ theory of disease do not perhaps apply to some other forms of a germ theory, one of which will be considered.

In order to make the conclusions at which I have arrived intelligible, it will be necessary for me in the first place to direct the reader's attention to some of the most important changes which occur in the living matter or bioplasm of the healthy tissues.

BIOPLASM AND ITS DEGRADATION.

THOSE marvellous progressive changes which occur during the development of the embryo, while the structures which characterise the organism are being evolved, are still but very imperfectly understood. We know, indeed, that all the complex tissues and organs of man and the higher animals are dependent for their production upon changes occurring in a minute mass of perfectly colourless living matter, in which no indications of form or structure can be discerned, but how these changes are brought about we have not yet been able to ascertain ; nor is it conveying much information to the student if the teacher informs him that the perfect organism, with all its marvellous apparatus, existed "potentially" in the little colourless living embryonic particle, since it would be impossible to distinguish the particle which was to develop a highly elaborate mechanism from that which was to produce a simple amœba, as its highest developmental product. Hence, while it cannot be said that the structures evolved "existed" in the original mass of living matter it will not make the assertion more correct if it be qualified by the term "potentially." All we know is that such and such structures result, but we know this from seeing them, not from *à priori* reasoning. For the characters and

composition of the living matter do not enable us to premise anything whatever as to its formative properties.

In the formation of man and the higher vertebrata the primary mass of bioplasm or living matter absorbs nutriment, and grows, and then divides and subdivides into numerous masses, which are arranged in a definite manner, but what determines this is not known. From each of these in pre-ordained order, and with perfect regularity, more are produced, no doubt, according to "laws," but laws about which we know nothing, except that if physical, they are very different from any physical laws yet discovered. As this process of division goes on, the resulting masses produce various substances, some having wonderful structure and properties. But the power of each series to produce these peculiar materials, which did not exist before, and which cannot be extracted from the food supplied, differs from that of the series which preceded it, and so on until the complex structural basis of the organism is as it were laid down.

There are developed masses of bioplasm to form nerve, others to produce muscle, others glands, and so on, all of which have been derived from one common mass, but the bioplasm destined to take part in the development of a gland will, under no circumstances, produce muscle or nerve.

And yet with all this marvellous difference in power, which if not acquired is at any rate manifested

as development advances, there is, as far as is known, no difference in matter which will account for the result. The nerve or muscle producing bioplasm is, as far as can be ascertained, the exact counterpart of the gland or bone forming bioplasm, and why one produces one tissue and the other a very different tissue cannot be explained; all these different forms of bioplasm have descended from one, which may be regarded as the parental mass, but in regular, definite, and *pre-arranged* order; so that if from any circumstance the bioplasm which is to form a gland or other organ, or a member, is not produced, and does not occupy its proper place at the right period of developmental progress, *that gland, organ, or member will be wanting in the particular organism.*

The manifestation of power or property to form special parts with special functions proceeds in regular order, progressively in one direction only as the germ advances towards the particular perfect form it is to attain. The power once lost can never be regained, although life may continue to be manifested nevertheless, and perhaps more actively than before. If the particles of bioplasm which were to take part in the development, say of the brain, do not receive at the proper period a supply of the right kind, or the proper proportion of nourishment; a well-developed healthy brain cannot in that case be formed. The particles may waste and die, or they may grow for a time and then cease to progress further; or they may

grow, and live, and multiply, and form a great mass of matter, which however will never produce a brain or an organ capable of performing the functions which the brain was designed to discharge. They may multiply fast, and take up more nourishment than the brain cells would have appropriated, had they been formed, but the organ with its marvellously complex intricate structure, which for its formation requires gradually progressive changes, steadily proceeding during a length of time, will never be produced; and under no circumstances conceivable could any of these masses, or any of their descendants, develop one perfect brain cell. If progress towards the mature state be stopped at any point the perfect state of development can never be reached, and the organism if developed must be imperfect. The development of other complex organs may have proceeded with perfect regularity, but the organism must ever remain incomplete in structure, and incapable of performing all the functions it might have discharged.

But although developmental power may be lost for ever, power of a different kind may be acquired *pari passu* during the rapid multiplication of bioplasm. Progressive advance in the capacity to form lasting structures and elaborate organs is characterised by the comparatively slow but regular and orderly growth and multiplication of bioplasm. Rapid multiplication, on the other hand, involves degradation

in formative power, which is at length entirely lost, never to be reacquired.

Degradation in power is commonly associated with increased rate of growth, increased faculty of resisting adverse conditions, and, in some cases, with such remarkable *vitality* of the living matter that it takes up more than the nourishment which should be appropriated by healthy parts. Consequently these last are at length starved and deteriorated or are completely destroyed. Nay, the actively living degraded bioplasm may retain its vitality although removed altogether and for some time from the living body, and it may grow and at length destroy other living organisms to which it gains access.

It is the main object of this work to show that a disease germ is probably a particle of living matter derived by direct descent from the living matter of man's organism, and I propose to give a sketch of some of the most important facts which have led me to adopt this view. The inquiry is of great interest, and affects the question of the nature of the material concerned in the propagation of contagious diseases. I shall also indicate how our views of treatment and more particularly how our efforts to extirpate the poison of contagious diseases and to prevent its production, will be influenced by the conclusions arrived at. In the first place I shall refer to the mode of multiplication of the bioplasm of man in health, and then endeavour to trace its degradation until a form

of bioplasm destructive of healthy life and capable of infinite multiplication results.

Bioplasm of Animals and Man in Health.

Bioplasm of Amœba.—Among the lower, simplest living forms known are some very simple organisms consisting apparently of transparent structureless semifluid material. Seldom indeed as much as the $\frac{1}{1000}$ of an inch in diameter, they vary much in size down to particles of extreme minuteness and tenuity only just visible under the highest power yet made, equalling about 5,000 diameters. These masses, apparently composed almost entirely of living matter, can move in any part, and in any direction (Figs. 29, 30, plate V.). Portions of the seemingly viscid or semifluid material may protrude in advance of the rest of the mass, and coming in contact with protrusions from other parts, join these, and thus may result a ring or a series of rings. The protrusion may be withdrawn and the whole assume the appearance of a perfectly smooth globular mass.

Such naked masses of living bioplasm or germinal matter may apply themselves to foreign bodies, and if these are small, completely invest them, so that the latter are at length seen in the interior of the mass embedded in its very substance. It is in this way that these simple forms of life are capable of effecting the solution of certain substances, and afterwards ap-

propriating them as nutrient materials. They increase in number in a very simple manner. If one of the protrusions above referred to be detached, artificially or by accident, a new and independent organism results. So long as a pedicle remains between the two, though it be so thin as to be only just visible, the diverticulum may be withdrawn, and the whole form one single spherical mass of living, growing, moving matter. But if the communication be once completely severed two separate beings result, and these can never again be incorporated so as to form but one.

Any one can study for himself the most important of the highly interesting phenomena which have been observed in these wonderful and simple organisms. Amœbæ can be readily obtained from water which has been left for a few days in a warm light room. Their growth can be watched from day to day, and their movements can be seen without difficulty. With the aid of high powers it will be found that the moving material is clear, transparent, and as far as we are able to discover, *destitute of structure,* exhibiting no appearance which could be reasonably supposed to be due to the presence of "molecular" or any kind of "machinery." It appears like homogeneous matter of syrupy consistence which moves in all directions. No one has been able to offer anything like an explanation of these movements although every one can see and study them without difficulty. Authorities have expressed them-

selves as if they had been able to give a full and sufficient explanation of the phenomenon, but there is nothing in their statements to justify the confidence which they seem to repose in the correctness of their views. The cause of these movements is unknown, if it is not unknowable. An attempt has been made to delineate the appearance of the moving matter in question in Plate V., fig. 30, which was examined under a power of 5,000 diameters. The difference in the shading indicates changes in thickness resulting from the movement.

Bioplasm of Bacteria.—If a large bacterium be crushed, the very simply living matter may sometimes be expressed from the envelope without injury, and may be seen to exhibit *vital movements,* while in the field of the microscope, Fig. 1. The progressional movements of many of the simplest organisms are effected by the bioplasm of their bodies protruding through the pores in their investing membrane or shell, by currents in the fluid caused by the movement of the living matter, and by the action of this same self-moving living material upon processes of the envelope or other passive organs composed of formed material projecting from different parts of the surface.

Vital Movements of Bioplasm.—These movements, which take place in every kind of bioplasm, or living matter, and which are to be observed so easily in the amœba, were formerly supposed to be peculiar to this organism. When it was discovered that the same

sort of motion was to be observed in the case of many of the lower forms of life and in the white blood corpuscle, it was spoken of as *amœbiform* or *amœboid*, as if the movements in question were connected with some mechanism or action peculiar to the amœba and the lowest forms of life. And even now the formation of "amœboid corpuscles" is spoken of as if it were some very special and exceptional phenomenon. The movement is, however, characteristic of the whole living world; but it is strictly confined to living beings, and nothing like it has been shown to occur in non-living matter. In man and the higher animals it is not always possible to see the movements of the bioplasm, for a very slight change in the circumstances under which life is carried on may cause its death; but in some cases, and these not a few, they may be seen in the living matter taken from man's organism, and from animals, both in health and also in the diseased state. See Plates XV., XVII., figs. 52, 54, fig. 60, pp. 46, 54.

As I have endeavoured to show, these movements are invariably limited to living matter (bioplasm). I have called this movement *vital* and have endeavoured to show that it is distinct from *muscular contractility, and from every other kind of movement known.* The vital movements of bioplasm vary remarkably in activity, and the same kind of living matter may move quickly or slowly according as the surrounding conditions change. Living particles transport them-

selves from place to place; they may insinuate themselves through the narrowest apertures, or creep through very minute fissures and channels. They may climb through water, and there is even reason to think they may move upwards through perfectly still air by virtue of their capacity for vital movement. The division and subdivision of living matter, and hence the multiplication of living beings, are among the results of vital movements. These vital movements too are the cause of many phenomena which are characteristic of man and the higher animals. That is, a chain of changes, each being a consequence of an antecedent change, may be traced backwards until at last we arrive at the movements occurring in the living matter, beyond which we cannot go; for we cannot ascertain the cause of these movements, although we know it must be closely related to *life* itself, for life cannot be conceived of without movement. The growth and multiplication of disease germs, their introduction into the body, their passage into the blood, and their subsequent wanderings, are intimately connected with their capacity for vital movement. Their formation I shall endeavour to prove is associated with greatly increased activity of vital movements, and the undue nutrition of certain forms of the bioplasm of the organism. In order to render intelligible to the reader the grounds of my views, it will be necessary in the first place to offer some general remarks concerning the nature and

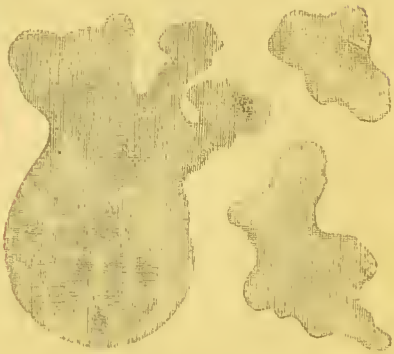
Fig. 28.

Bioplasm or living matter from a crushed bacterium showing the changes in form which occurred during a few seconds. × 1800. p. 97.

Fig. 29.

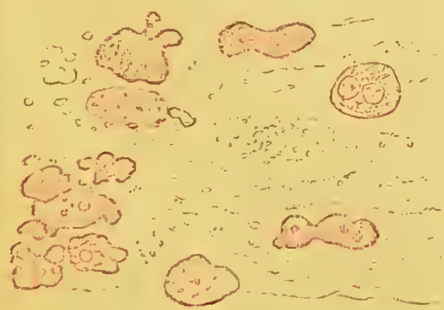
A small amœba, magnified by the $\frac{1}{50}$ = 2800 diameters. 1867. p. 96.

Fig. 30.



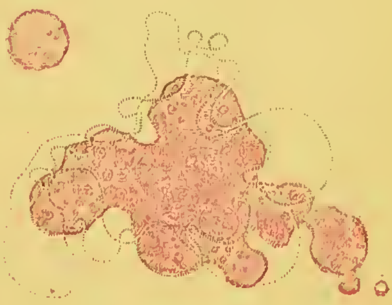
Very minute living amœbæ, magnified 5000 diameters. p. 96.

Fig. 31.



Mucus from the trachea during life, magnified 700 diameters. p. 101.

Fig. 32.



One of the living mucus corpuscles represented in Fig. 4, magnified by the $\frac{1}{50}$ = 2800 diameters, showing alterations in form during one minute. p. 101.

$\frac{1}{10,000}$th of an inch — × 700 linear.
" " — × 2800.
" " — × 5000.

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growth of the bioplasm of the higher animals and man.

The Living Matter or Bioplasm of Mucus.—If a little mucus which collects commonly enough upon the soft mucous membrane of the air passages be examined upon a warm glass slide, with the aid of a power magnifying 700 diameters, or upwards, little oval masses of germinal matter not unlike amœbæ will be seen in great numbers embedded in the viscid transparent material which gives to the mucus its properties, and which has been formed by the particles of the bioplasm, Fig. 31, plate V.

By attentive examination movements will be observed in many of these masses, not unlike those above described in the case of the amœba. Fig. 32 represents the changes in form in a living mucus corpuscle under a power of 2,800. If the distribution of nutriment to the mucus be increased, the bioplasts enlarge, and divide and subdivide until vast numbers result. In some cases of inflammation of the mucous membrane all the viscid matter secreted upon the surface appears to consist of bioplasts ordinarily termed *pus corpuscles*, while on the other hand the proportion of formed material which was abundant in ordinary mucus is exceedingly small. The bioplasm has multiplied so fast that there has not been time for the production even of the soft mucus.

Vital movements resembling those which have been described in the amœba, in the bioplasm of mucus,

and in white or colourless corpuscles may be seen, but not so easily, in the bioplasm of young epithelial cells, in that of cartilage, the cornea, connective tissue, and other textures, and there can be no doubt whatever that all bioplasm possesses the power of movement, and that by virtue of this power of movement the several masses are able to take up the positions they respectively occupy in all the different tissues which they form, and in the preservation and maintenance of which, in a state of integrity, they play so highly important a part as long as life lasts.

Embryonic Bioplasm.—The growth and multiplication of bioplasm at an early period of development may be studied in an embryo, and many highly important observations may be made if the growing tissues of the chrysalis of the common blow-fly be submitted to examination, especially when they have been successfully stained by the carmine fluid. A mass of formless bioplasm invariably represents the earliest stage of development of every tissue and organ. The bioplasm, which is concerned in the formation of the special tissues, emanates from this, and in many cases a sort of temporary structure is formed in the first instance in which the development of the higher tissue afterwards takes place. Some suppose that the particles of bioplasm are formed *anew*, but this is certainly not the case. They have been invariably derived from pre-existing bioplasm. In the formation of the tissues of the imago or perfect insect

during the chrysalis state, each texture is developed anew from bioplasm, but this was derived from the bioplasm of the larva. If one of the growing extremities of a fœtal tuft of the placenta be examined, it will be found that the material which advances first, which grows away as it were from the tissue which is already formed, is a mass of bioplasm, which is divided and subdivided into smaller portions, as represented in Fig. 33, plate VI. The loop of vessels gradually increases in the wake of this little collection of living matter which continues to move onwards as long as the placenta continues to grow. These little collections of bioplasm bifurcate, and thus form branches into which vascular loops afterwards proceed. As in every other instance, the first changes are produced by bioplasm ; and by this living matter every kind of growth and development is effected.

White Blood Corpuscles or Blood Bioplasts.—If a drop of blood be obtained from the finger by pricking it with a needle, and allowed to fall upon a glass slide slightly warmed, covered with thin glass, and carefully pressed, and then examined under a power of 700 diameters or upwards, here and there, colourless slightly granular, apparently spherical bodies will be seen amongst multitudes of the well-known red blood-corpuscles. These are the so-called white or colourless blood-corpuscles (Plate XVI, fig. 55). They consist of living bioplasm or germinal matter, and exhibit movements like those referred to in the amœba and

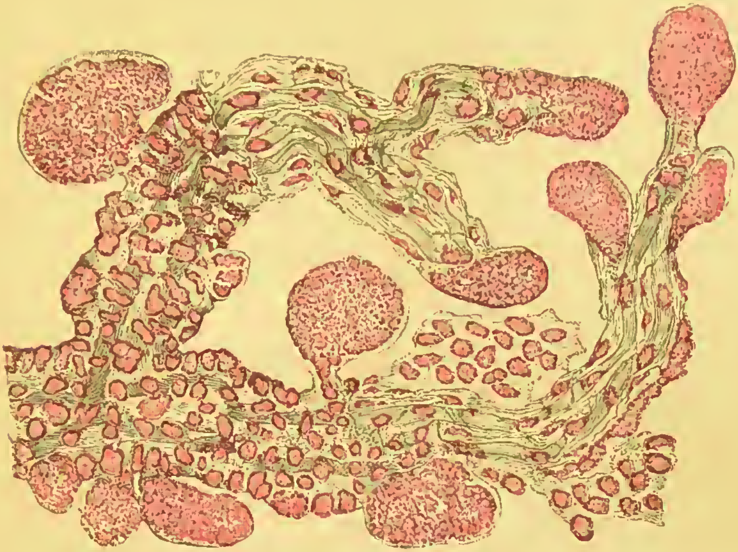
I 2

in the mucus corpuscle. The movements continue for many hours after the blood has been withdrawn from the body. The colourless as well as the red blood-corpuscles vary much in size, although they are often represented as if they were of uniform diameter. These bioplasts multiply by giving off little diverticula, which become detached, and then grow into complete corpuscles. In the blood there are, besides the white blood-corpusles, multitudes of minute masses of living matter, probably composed of the same material as the white blood-corpuscles. These were described and figured by me in 1863, and I showed that when the capillary walls became stretched by distension they would escape through little longitudinal rents or fissures into the spaces external to the vessels, where, being freely supplied with nutrient matter, they grew and multiplied, giving rise to the numerous corpuscles seen in this situation in inflammation. These minute particles are indeed the most important constituents of inflammatory exudation, and are the agents by which the important changes occurring in the exudation are effected. They vary much in number in the blood and are very abundant in inflammation.

Whenever the circulation is carried on slowly in any part of the body *the colourless or white blood-corpuscles grow and multiply*, and at an early period of development, before the heart and lungs are fully formed, the only corpuscles are these white or colourless

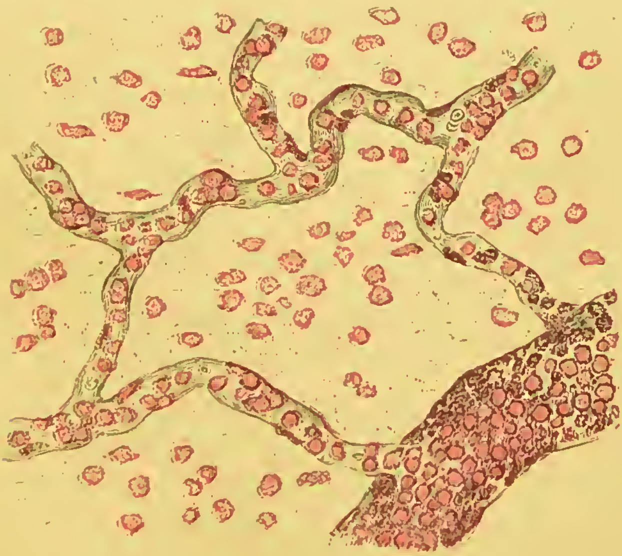
INCREASE OF BIOPLASM.—DEVELOPMENT OF VESSELS AND OTHER TISSUES.

Fig. 33.



Growing extremities of fœtal tufts from human placenta, 7th month. × 215. At every extremity is seen a collection of small masses of bioplasm which are undergoing division. Each collection advances, and the vessels and other structures grow in its wake as it were. The masses of bioplasm of the capillaries and other structures entering into the formation of the tuft are also well seen. 1864. p. 103.

Fig. 34.



Capillary vessels opening into a small vein. Pia mater. Human fœtus, fifth month of intra-uterine life. The capillaries contain numerous white blood corpuscles (bioplasm) which are coloured by carmine, and the vein is completely filled with them. Very few red blood corpuscles were present. × 215. p. 105.

$\frac{1}{1000}$ of an inch × 215 linear.

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blood-corpuscles. This important fact may be easily demonstrated if the blood in any of the small vessels of the embryo of a vertebrate animal be examined. A very striking and beautiful example is represented in Fig. 35, plate VII, from the ovum of the turtle. The capillaries are seen to be filled with living growing blood bioplasts (white blood-corpuscles) every one of which has been well coloured by carmine fluid, and can therefore be very distinctly seen in the specimen. Only here and there could a red blood-corpuscle be discovered.

In Fig. 34, plate VI, I have given a drawing of part of a small vein, with a few capillaries opening into it, from a beautiful specimen of the *pia mater*, covering the hemispheres of the brain of a human embryo at the fifth month of intra-uterine life. This illustrates the same fact. The little veins were quite filled with blood bioplasts, very few of which had as yet become developed into red blood-corpuscles. In the capillaries represented in this drawing will be seen many very minute bioplasts which have been detached from larger ones and are growing. The bioplasts seen in the capillary interspaces are those which take part in the development of the other textures of which the *pia mater* is constituted.

In animals which hybernate, or which have been kept inactive in confinement for some time, and in man, under certain circumstances, many of the red blood-corpuscles in the blood-vessels are absorbed,

just as they are from a clot formed in any of the smaller vessels, and in some instances from a clot situated external to the vessels, and the living bioplasts (white blood-corpuscles) grow and multiply at their expense. After a time, such is the increase of the latter that the capillaries in many tissues are almost entirely occupied by them. This fact is illustrated by Fig. 36, plate VIII, which represents very small capillary vessels of the mesentery of the common frog in winter. The vessel is almost choked up with white blood-corpuscles, only one or two red ones remaining in the specimen from which the drawing was taken. Another illustration of this fact is given in Fig. 37, plate VIII, which represents some of the capillaries from the bladder of a half-starved frog. The capillaries have much wasted, and contain no red blood-corpuscles whatever, their cavity being entirely occupied by fluid liquor sanguinis and masses of bioplasm, differing much in size, the largest particles having the ordinary dimensions of the white blood-corpuscles, while the smallest are so minute that they cannot be demonstrated under a power magnifying much less than 1,000 diameters. It is remarkable that in this case the white blood-corpuscles are still growing and multiplying, and are, indeed, probably the active agents in the absorption of the tissues. In this specimen taken from the most beautiful and delicate of all the tissues of the frog may also be seen the very fine pale nerve-fibres which I demonstrated

BLOOD BIOPLASTS, OR, WHITE BLOOD CORPUSCLES IN VESSELS OF EMBRYO.

Fig. 35.

a

Capillary vessels and small vein from the ovum of the turtle at an early period of development. The vessels were entirely filled with white blood corpuscles, and in some places they were completely distended with them. Developing connective tissue with connective tissue corpuscles, fat cells, and perhaps nerve fibres are also seen. To the right of the drawing at *a* will be observed a very young capillary, the tube of which is not yet wide enough to allow a blood corpuscle to pass through it. × 215. 1864 p. 105

$\frac{1}{1000}$ of an inch —— × 215 linear.

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some years ago. A fine bundle is seen at *a*, from which point it may be readily followed, as it divides into finer branches, ramifications of which are seen in every part of the drawing. The bundles of unstriped muscular fibres are marked *b*, while the bioplasm masses of the connective tissue corpuscles are represented here and there in the intervals.

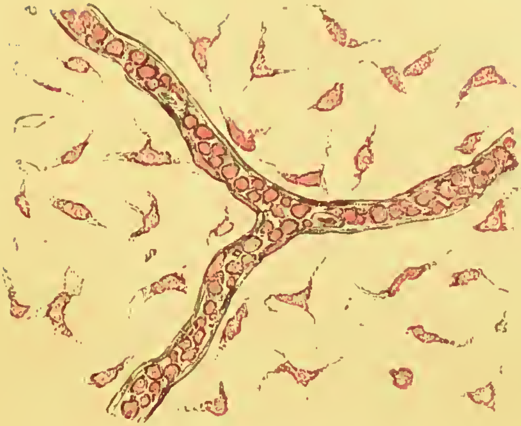
So far I have endeavoured to show that the masses of germinal matter or bioplasm which are to be found in all parts of the tissues of man and the higher animals at every period of life, and suspended in the nutrient fluids, notwithstanding very remarkable differences in power, exhibit the same general characters as those manifested by the living matter of the lowest animals and plants. In all cases it is the bioplasm only which lives and grows and multiplies. Moreover, attention has been especially directed to the fact that the rate of growth of the bioplasm varies according to the scarcity or abundance of the nutrient material, and to the rapidity of its access. The bioplasts (white blood-corpuscles) of the blood increase in number, when the fluid in which they are suspended moves slowly as at an early period of life before the propelling apparatus is fully developed, or at any period of life when the circulation is retarded from any cause whatever.

This remarkable growth and multiplication of the blood bioplasts seems to be determined by the altered conditions under which life is carried on without any

derangement of the health necessarily accompanying the change. The fact of the increase of the white blood-corpuscles in apparently opposite conditions of the system receives a simple explanation. A hybernating animal cannot be said to be suffering from disease, but nevertheless the blood in his capillary vessels contains a vastly increased number of bioplasts, and could hardly be distinguished from blood which was stagnating in consequence of something impeding the circulation—a state of things which would be rightly regarded as disease. In this part of the inquiry we seem indeed to be on the very confines of disease ; in a sort of border-land where the healthy process may so gradually and imperceptibly pass into the morbid process that it would not be possible to draw a distinction in words, nor would the appearances which may be demonstrated by the eye enable us to define with greater exactness the special condition. In fact, up to this point there is no real difference. The state of things I have described, if it continues and if it leads to other changes, would be considered evidence of disease. If, on the other hand, the circulation soon returned to its normal rate, the increased number of white blood-corpuscles in the capillaries would soon pass into the circulation and become lost in the mass of the blood, where they would undergo further changes. There would be no stronger evidence of even a temporary disturbance of the healthy condition than was afforded perhaps by some trivial

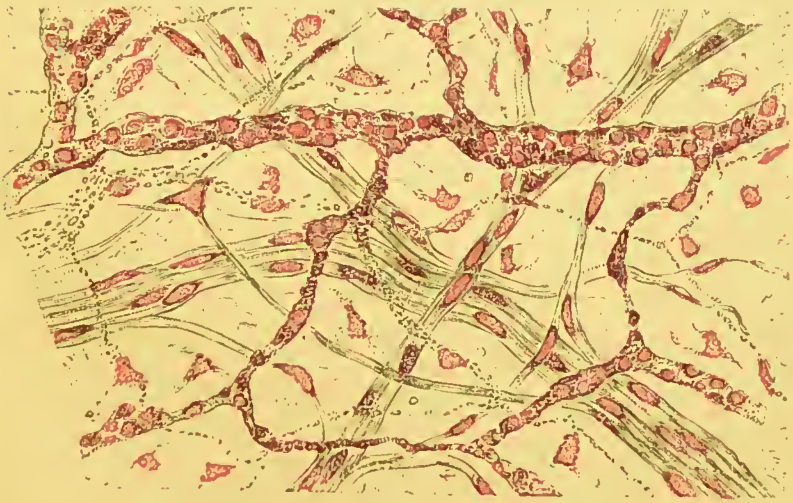
BIOPLASM IN BLOOD VESSELS.

Fig. 36.



Capillary vessels and connective tissue, and connective tissue corpuscles. Mesentery. Frog in winter. The capillaries are filled with numerous white blood corpuscles (bioplasm). Only one or two red blood corpuscles were present. × 215. p. 106

Fig. 37.



Bladder of a frog which was half starved. The capillaries are wasting, and contain bioplasm only. No red blood corpuscles could be detected. Bundles of unstriped muscle are seen ramifying over the field. Some have fibres radiating in three directions, and the bioplasm of these is triangular *b*. At *a*, a bundle of very fine nerve fibres is represented. Its ramifications may be followed over every part of the specimen. The bioplasm of the connective tissue is also represented. Thus, *all* the tissues of the thin bladder are demonstrated. × 215. The drawing was taken from a specimen mounted in 1862. × 215, p. 106.

$\frac{1}{1000}$ of an inch = × 215 linear.

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nervous derangement possibly, giving rise, in the case of man and the higher animals to slight pain, which might soon pass off, or perhaps escape notice altogether.

These blood bioplasts possess formative power of a very remarkable kind even in the adult. Not only are they capable of producing fibrin, but they or bioplasts directly descended from them, are capable of forming fibrous tissue which resembles the ordinary fibrous tissue developed in connection with several textures of the body. But; more than this, these bioplasts, poured out from the vessels suspended in fluid exudation, or their descendants growing and multiplying upon a surface wound of the skin or a mucous membrane may produce cuticular cells or the epithlial particles of a mucous membrane, not perhaps quite so perfect and well formed as those developed *in situ*, but nevertheless efficient as a protecting covering. The varied power of forming tissue possessed by these bioplasts is perhaps due to the circumstance that they have inherited formative powers from the bioplasts of the germinal area at an early period of development, for it must be remembered that the ancestral white blood-corpuscles from which all have directly descended, were developed at a time anterior to that when the various bioplasts taking part in the formation of the tissues diverged from their common progenitor. So that formative power of a more general character than is possessed by the

bioplasts of the tissues might be expected to belong to the blood bioplasts. And in the case of some of the lower animals which exhibit the power of reproduction of lost parts and organs, it appears very probable that the agents directly concerned in the development of these are bodies resembling the blood bioplasts ; and that from them result masses of bioplasm which take part in the formation of the several tissues of which the new member is constituted.

Bioplasm of the Tissues of the Adult.—As the tissues are formed by the conversion of the outer part of each bioplasm mass into the formed material or tissue, the distance by which the several masses of bioplasm are separated from one another becomes greater. This important fact may be demonstrated in almost any tissue of a young or adult animal. In Figs. 38 and 39, plate IX, are represented young and fully formed cuticle of the newt from the very same spot of skin. The formed material of the cuticular tissue accumulates around each mass of bioplasm until the well known adult "cuticular cell" results, Fig. 39.

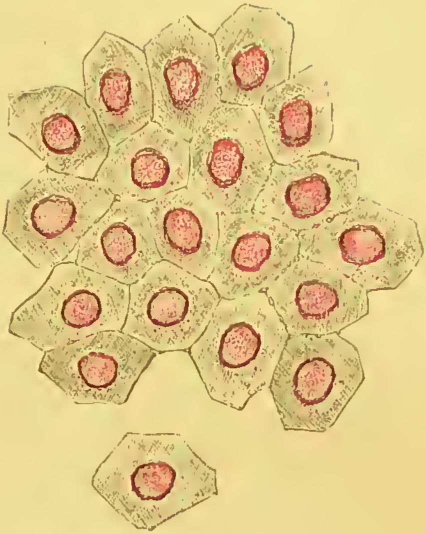
Again, in Figs. 40 and 41, the appearance of sections of permanent cartilage from the same part of the body is given under a power of 700 diameters. At an early period of development "tissue" scarcely exists, and all that can be discovered is bioplasm. In young tissue, at all periods of life, the same fact is observed, but as the textures advance towards maturity the proportion of bioplasm in a given bulk of

BIOPLASM OF FULLY FORMED TISSUES.

Fig. 38.

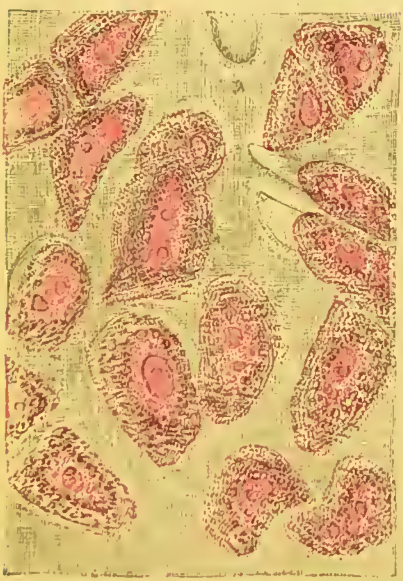
Cuticle Newt. Deep layer, consisting of bioplasm with very little formed material. × 215. p. 110.

Fig. 39.



Cuticle. Newt. Superficial layer, showing each mass of bioplasm surrounded by its formed material. × 215. p. 110.

Fig. 40.



Cartilage rib of kitten at birth, showing large masses of bioplasm with very little formed material between them. × 700. p. 110.

Fig. 41.

Cartilage rib of young cat, showing diminished size of masses of bioplasm and great increase of matrix or formed material of cartilage. × 700.

$\frac{1}{1000}$ of an inch × 215 linear.

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texture becomes less. Now in disease we shall find that in adult tissues the bioplasm increases, and that the general appearance assumed is that which embryonic tissue presents, indeed some "inflamed" textures might be mistaken for embryonic tissue.

From Health to Disease.

I have endeavoured to show that the only material in the organisms of living beings capable of growth and multiplication is that which I have recently named *bioplasm*, hitherto known as *germinal or living matter.* In fully formed tissues the proportion of this is very small. Still, all active change which takes place in the tissue depends upon this living matter, however little there may be. If there be none, the tissue *is as incapable of undergoing active changes as if it did not form a part of the body.* The smallest particle of bioplasm possesses active powers, and if supplied with proper pabulum, soon grows. Each little bioplast grows, that is, increases, by taking up material differing entirely from it in composition, properties, and powers, and converts certain elements of this into matter identical with that of which it consists. After the bioplasm-particle has reached a certain size, division occurs. Instead of growing larger and larger, and forming a continuous mass of enormous size, as some have fancifully supposed exists at the bottom of the ocean, portions are from time to time detached.

These separate themselves and move away from the parent mass. Each of these little germs has properties in many respects like those of the parent mass, though it may possess the capacity for forming matters which the parent mass could not have produced. Each bioplasm particle lives and grows, attains a certain size, and may produce its kind in the same way.

Now, the whole human organism at a very early early period of its development consisted entirely of little masses of living bioplasm like those above referred to. Each of these grew and divided and subdivided, so that multitudes at length resulted from the division of a few. All were descendants of the first primitive germinal mass, which was itself derived from pre-existing germinal matter. After a time some of the bioplasm particles cease to multiply, though they still live and take up food. The living matter of which they are composed undergoes change. It dies under certain conditions, and "tissue" results. In this way muscle, and nerve, and fibrous tissue, and bone, and hair, and horn, and nail, and all other textures, are formed. In the adult, however, there remain some masses of germinal matter which go on growing and dividing just as all grew and multiplied in the embryo. Among these are the white or colourless blood-corpuscles, which possess formative power even in old age in greater degree than any other form of bioplasm in the adult, as has

been already shown. At the deep aspect of the cuticle and below the fully formed epithelium of mucous membranes and some glandular organs, are masses of germinal matter, which continue to divide and subdivide in the same way throughout life. These, in the ordinary course, move towards the surface, and as they move, each gradually forms upon its surface the hard cuticular matter (cell-wall) to which the properties of the epidermis are due, see Plate IX, fig. 39.

It has been already said that the bioplastic masses of different organisms, and those in different parts of the same organism, possess different endowments. For from one kind of bioplasm is formed muscle, from another nerve, from another fat, and so forth, but yet all these kinds have directly descended from one. They could not be distinguished from one another, nor from the primary mass from which they came, by any microscopical or chemical characters. Neither could one of these kinds of bioplasm in the adult develop a mass capable of producing the rest. Although no one could distinguish one particle from the other, each will produce its kind, and that alone. It would be as unreasonable to expect an amœba to result from a pus-corpuscle, or from a yeast particle, or to suppose that by any alteration in food or management a cabbage would spring from a mustard seed, or the modern white mouse from the descendant of an ancestral white rabbit, as it would be to maintain

that muscle, nerve, brain, gland, or other special tissue might be produced indiscriminately by any mass of bioplasm of the adult, supposing that the conditions under which it lived were changed to any possible extent. Its vital powers, which are within, and upon which the capacity to develop depends, cannot be thus changed by any mere alteration in external circumstances.

The Pus-Bioplast derived from the Germinal Matter of all the Tissues.—But it is certainly very remarkable that the many kinds of germinal matter of the organism of man and the higher animals, though differing so much in power or property that one produces nerve, another muscle, a third bone, a fourth fat, and so on, will each under certain conditions give rise to a *common form of germinal matter or bioplasm differing in properties and powers from them all.* This is the form of bioplasm known as *pus,* which may go on multiplying for any length of time, producing successive generations of pus-bioplasts, which exhibit remarkable vital properties, although they cannot form tissue, nor produce tissue-forming bioplasts of any kind whatever.

It is evident from this that the power is manifested in one direction only—onwards. Embryonic living matter or bioplasm gives rise to several different kinds, not one of which can produce matter having precisely the same endowments as that which existed immediately before it, and from which it sprang. And

yet every kind of germinal matter exhibits powers of infinite growth.*

When bioplasm or germinal matter lives faster than in health, in consequence of being supplied with an undue proportion of nutrient material, a morbid bioplasm results ; and if the process continues for a short time, changes familiar to those conversant with pathological alterations occur upon a large scale.

Of Retrogression in Formative Power.—In discussing questions of this kind, involving such minute details, we must be most careful to avoid too hasty generalization, and must proceed by very slow steps. This is more particularly necessary if it so happens that our inferences in some measure accord with the views of speculative and enthusiastic persons, who are always fancying that we are on the eve of some grand discovery which is to revolutionize thought. Many, from a consideration of the arguments I have advanced, would perhaps be led to look with favour upon the doctrine that the lowest living forms are capable of being produced by the retrograde development of higher forms, and that bioplasm even very high in the

* While, however, the process of division is proceeding, as has been described, in some cases a small portion of the germinal matter does not undergo division into masses of the next series, but retains its primitive powers. This remains in an embryonic condition after the tissue has been formed, and thus the development of new tissue, even in advanced life, is, in some cases, not only possible, but actually occurs. Many cancers and other morbid growths probably originate in these masses of embryo bioplasm which remain for a long time in a quiescent state embedded in some of the fully-formed textures of the adult.

scale of organization, may give rise to forms of bioplasm approximating more and more closely to the lowest constant forms of life with which we are acquainted. A doctrine asserting that by continual retrogression through ages, the descendants of the highest forms would gradually deteriorate until their only remaining representatives were monads, would not be very easily disproved, and might be supported by many ingenious arguments. It is a view that doubtless would recommend itself to many minds in the present day.

But on the other hand it is obvious that cells and organisms might retrograde and produce various modified forms, without giving rise to any of those particular forms characteristic of the lower organisms which we are acquainted with. Nay, cells of different organisms might give rise to many different retrograde forms, and every one of these be very different from one another, and yet totally unlike any known organism. It is obviously possible that there should be infinite advance and infinite retrogression in multitudes of parallel lines, as it were, without the resulting forms of any one line becoming identical with those of another. Just as it is possible to conceive infinite advance in the features of the dog, without any resemblance whatever to the human face resulting, and retrogression and deterioration of the latter proceeding to any degree, and continuing for any length of time, without the production of the simian type of countenance.

Sufficient allowance is not made by many thinkers for the infinity of difference even in structure, and variety of change, *possible* in living forms, without the production of two things alike, or any indication of the merging of one set of forms into another. It must not be forgotten for an instant that from such a marvellous storehouse of facts as is placed at our disposal in nature, we may with very little ingenuity select certain series of facts in favour of several very different general hypotheses ; and however conflicting these may be with one another, it may not be possible to disprove any one of them in the present state of knowledge. The fact that masses of germinal matter, derived by direct descent from cells of one of the lower animals, may grow and multiply in man's organism, and *vice versâ*, might be adduced as an argument in favour of the original common parentage, countless ages back, of the predecessors of both ; but there are, it need scarcely be said, facts and arguments tending to a different conclusion, and these must not be lost sight of in our attempts to ascertain the truth.

It is not improbable that the germinal matter of some of the lower, simpler plants and animals, when exposed to altered conditions, may give rise to morbid forms bearing a relation to their normal healthy living germinal matter, similar to that which pus bears to the germinal matter of healthy tissues, and it is possible that in our observations upon the lower forms of life we may be sometimes examining

morbid instead of normal healthy organisms. It may be that the matter of the malarial poison may thus result, in which case it must be regarded as a morbid bioplasm of some low organism,—not as a *species* of any kind whatever,—but as a deteriorated form of living matter freely multiplying but incapable of producing healthy matter or of returning to its primitive healthy state.

I propose now to draw attention to the facts I have been able to observe in connection with the deterioration in power of bioplasm during that increased multiplication which results from the very free supply of pabulum, and which may at last lead to the production of diseased germs.

Bioplasm of Epithelium.—When the germinal matter of the epithelial cells of certain mucous membranes, or that of other tissues of the body, or the germinal matter of the white blood-corpuscles, lives faster than in health, in consequence of being supplied with an undue proportion of nutrient material, it grows and multiplies to an enormous extent; so that one mass may perhaps be the parent of five hundred, in the time which, in a perfectly healthy state, would be occupied in the production of two or three cells. And in some ordinarily very slowly-growing tissues, the germinal matter may in disease divide and subdivide very quickly, although in the healthy state it would undergo scarcely any appreciable change in the course, perhaps, of several weeks or months. The

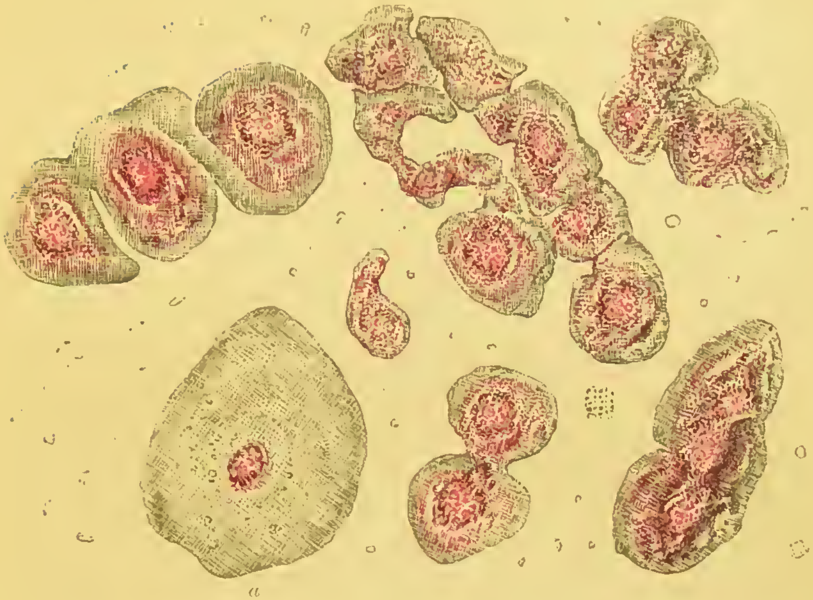
increased rate of access of nutrient material to the living matter is the necessary condition of its increase. The living matter always *tends* to increase, but in the normal state of things it is only permitted to do so at a certain regular rate, which is determined by the even distribution and somewhat limited access of the nutrient material.

In certain cases in which an increased proportion of nutrient material is distributed to the epithelium of the mucous membrane,—as, for example, to that of the fauces,—the young epithelial cells grow and multiply so rapidly that the superficial layers of older and hardened structure become detached, and upon the free surface is produced a thick layer of soft, spongy, epithelial elements, with, in many instances, but faint indications of division into individual epithelial particles, Fig. 42, plate X. In fact, under the circumstances alluded to, growth takes place too rapidly for the formation of the characteristic hardened epithelial texture, though the changes are not so rapid as to lead to the formation of actual pus. The spongy texture produced may be regarded as occupying a position midway between healthy epithelial tissue and the pathological bioplasm, pus. I have examined the young rapidly-growing, but as yet imperfectly-formed epithelial particles, in specimens taken from the surface of the pharynx in a case of slight sore-throat coming on in a person enjoying ordinarily good health ; some of these are represented

in Fig. 42 under a power magnifying 700. The mode in which the masses divide and subdivide could be well seen, and the thick plastic character of the matter of which they are composed has been carefully given in drawings. The greater part of the material consists of living matter or bioplasm, some of which has probably undergone conversion into soft-formed material, which, however, still remains mingled with it. From any part of one of these masses diverticula might have been formed, and thus new bioplasts, each capable of undergoing conversion into an epithelial cell, would result. Many epithelial formations exhibit much the same changes in disease, and the transition from the healthy to the morbid state is beautifully indicated (Fig. 43). Nay, we may almost conceive that it is by unremitting continuance of this very process, combined with irregularity in the rate of multiplication of contiguous particles, that the remarkable pathological formation of epithelial cancer results (Fig. 44, pl. X.).

If, then, the bioplasts of a tissue receive an unusually abundant supply of nutrient matter, they grow and multiply just like the amœba, the white blood-corpuscle, the mucus-corpuscle, and the pus-corpuscle, and they may give origin to pus. Masses of bioplasm which under ordinary circumstances would form cuticle, grow and live so very fast, that there is not time for their cuticle-forming property to manifest itself. The changes are well shown in Fig. 45, pl. XI.,

Fig. 42.



Epithelium from the surface of the pharynx of a healthy person suffering from very slight sore throat, a day after 'catching cold.' *a* a normal full grown epithelial cell for contrasting with the other specimens in which the proportions of germinal matter is very great and the formed material still plastic and containing very much bioplasm in some instances dependent upon very rapid growth. × 700. p. 119.

Fig. 43.

Some of the smallest cells in white mucus from the smallest bronchial tubes of a cow which died from cattle plague. The bioplasm has increased in quantity. The animal was warm when examined. × 1800. p. 119.

Fig. 44.

Cancer cells from a case of epithelial cancer of the bladder, showing growth and multiplication of the bioplasm which exists in large quantity. × 215 p. 120.

$\frac{1}{10000}$th of an inch = × 700 linear.

" ——— × 1800.

to the left of which, at *a b c d*, are represented separate cells, the bioplasm of which is growing and dividing and subdividing. The cells multiply faster than any cuticle cells, and the numerous descendants they produce are pus-corpuscles, Figs. 46, 47. From these pus-bioplasts, diverticula, proceed, and particles are from time to time detached which are extremely minute, and by their movements may pass through very narrow chinks in tissues, and thus spread from the point where they were first produced : not only so, but some of these are so minute, that, like the little germs detached from the yeast cells and other microscopic fungi, the amœba germ, and many others, air will support them ; they may thus be carried long distances from the spot where they were developed. If exposed to great heat or cold, or to the action of certain gases and vapours, they will be killed, but in warm, moist air they will live ; and if they fall in a favourable place, that is, where there is proper food for them, they will grow and multiply a thousandfold like yeast. But the yeast germ is essentially different from these, and will not produce amœba, or the latter pus. The pabulum suitable for the first would kill the last.

Multiplication of Blood-bioplasts in Disease.—Next, then, let us consider whether the multiplication of the bioplasts (masses of germinal matter) of the blood which occurs in the capillary vessels *in disease*, differs from the process which we have seen going on in the vessels of all animals at an early period of develop-

ment, and throughout life at a certain time of the year in the case of hybernating animals, and in man under physiological conditions which cause the blood to circulate very slowly, or to stagnate for a time in the smaller vessels of the body. As will be inferred from the remarks made in pp. 108, 119, it is not possible to draw any distinct line of demarcation between physiological and pathological changes. In *inflammation*, the phenomena above referred to proceed a stage further, and then are unquestionably pathological. But even if this stage be reached, it by no means follows that the texture involved should not regain its normal condition and the previous healthy state be perfectly restored.

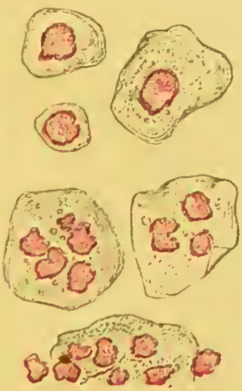
On the other hand, it is quite certain that if the state of things now to be described continues for a time, and proceeds to any great extent, destruction of tissue is inevitable and return to the original condition is rendered impossible. *Repair* may follow the injury, but this *repair* involves serious alteration in structure, with corresponding deterioration in action, without capacity for improvement and without the possibility, under any circumstances, of return to the former state.

When the circulation through the capillary vessels is impeded in many cases of fever, inflammation, and other diseases, the blood bioplasts (white blood-corpuscles) multiply, and the capillaries often appear to be filled with them. The vessels and their

Fig. 45.

A portion of the epithelial covering of the tongue in a state of inflammation. The bioplasm at the lower part is growing and multiplying very rapidly. The changes taking place in individual cells or elementary parts are represented on the right, at *a*, *b*, *c*, *d*. × 700. This drawing has not been copied from a single preparation, but has been completed from the appearances observed in several different specimens. p. 119.

Fig. 46.



Increase of bioplasm and formation of pus in individual epithelial cells of mucous membrane. Mouth. × 215. p. 121.

Fig. 47.

Division of bioplasm in cells of bladder epithelium. From a case of inflammation of the bladder. × 215.

$\frac{1}{1000}$ of an inch ——— × 215 linear.

contents then very closely resemble those of an animal during the early period of its development. This state of things always exists in inflammation, and the multiplication of the bioplasts often proceeds to a wonderful extent. The appearances seen are certainly not due simply to the *accumulation* of white blood-corpuscles, as some have held, but only in part to this, and mainly, as I pointed out many years ago, to their actual growth and increase. "If in any capillaries of the body the circulation is retarded from any cause, an increase in the white blood-corpuscles invariably takes place. In congestion and inflammation of the vessels of the frog's foot, the number of the white blood-corpuscles soon becomes so great as to impede and ultimately to stop the circulation through the vessel. Although the great majority are merely corpuscles that have been retarded in their passage, there can be little doubt that the corpuscles actually multiply in number in the clot that is formed."* In Fig. 51, plate XIV, p. 128, a very small vein with two capillaries from the frog's foot a few hours after inflammation had commenced, is represented under a magnifying power of 215 diameters. The white blood-corpuscles form a thick layer all round the vessel, the circulation had quite ceased, and the entire tube would soon have been entirely occupied by white blood-corpuscles. The little capillaries are quite

* "On the Germinal Matter of the Blood, with Remarks upon the Formation of Fibrin," December 9th, 1863, 'Trans. of the Mic. Soc.'

occluded. The liquor sanguinis is transuding through their walls, and in a very short time the minute vessels would have appeared quite filled with bioplasm, and the growth of the living matter from the minute particles of bioplasm which escaped when they were distended, would soon have commenced as in Figs. 48, 49, 50, plates XII, XIII, XIV. The fact of the *increase* of the white blood-corpuscles appears to have been overlooked in consequence of the preparation of the specimens not having been conducted with sufficient care to permit of examination being made with powers of high magnifying power.

Whenever a capillary vessel is distended, its walls necessarily become much reduced in thickness, and in extreme distension which occurs in inflammation, little longitudinal rents or fissures are here and there produced. Through these, serum, holding in suspension very minute bioplasts probably detached from the larger ones growing and multiplying in the vessel, pass. Having thus extravasated, these particles, resulting directly from the subdivision of the white blood-corpuscles, make their way by vital movements into the interstices of the surrounding tissues, and being nearly stationary, and abundantly supplied with nutrient pabulum, grow and multiply in the new locality, and at an increasing rate. The phenomena here described will be understood if the figures given in Plates XII, XIII, and XIV be carefully studied. These have been copied from preparations which were pre-

INCREASE OF BIOPLASM IN INFLAMMATION.

Fig. 48.

Portion of pectoral muscle, frog, forty-eight hours after being perforated. × 50. Showing increased growth of bioplasm in all the tissues. The vessels contain an increased number of white blood corpuscles (bioplasm), and the bioplasm masses of the muscles are already dividing and subdividing. The elementary muscular fibres have in several instances ruptured and contracted within the tube of the sarcolemma. From a specimen mounted in 1863. p. 124.

$\frac{1}{1000}$ of an inch = × 50 linear.

L. S. B.] 1870.

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pared in the year 1863. But the facts demonstrated were well known to me, had been described in my lectures before 1863, and were particularly referred to in a paper presented to the Royal Microscopical Society in that year. I did not come to the conclusion which has since been adopted by Cohnheim, that an individual white blood-corpuscle passed through the wall of the vessel, and then changed its characters and became a pus-corpuscle, an idea which had been previously advanced by W. Addison and also by Waller; but my observations led me to believe--and of the correctness of the conclusion I am fully satisfied —that the particles of germinal or living matter seen in such great numbers outside the vessels in cases of inflammation, result for the most part from the growth, division, and subdivision of minute particles of germinal matter which have passed through the vascular wall suspended in the fluid exudation. Many of the masses of germinal matter represented in Fig. 50, pl. XIV, are the descendants of white blood-corpuscles, but they are not the white blood-corpuscles which were previously in the blood, and which were circulating in that fluid. They may continue to grow and multiply like other kinds of germinal matter, until at last that rapidly-growing form of bioplasm, the common result of the greatly-increased growth and multiplication of every form of bioplasm in the living body, may be produced. In inflammation of a texture going on to pus-formation,—of the pus-corpuscles in

the abscess, some are descendants of white blood-corpuscles, others of the bioplasm of the tissue, vessels, and nerves. The *pus-corpuscle* may therefore be a descendant of the white blood-corpuscle, as well as of the germinal matter of epithelium, and of other tissues. We may, indeed, trace back its parentage to the original embryonic bioplasmic mass, which must be regarded as the primitive ancestor of all.

New Observations on the Growth and Multiplication of Pus.—The researches upon which the conclusions here briefly expressed, are based, have proved, I think, as I showed in the first course of lectures which I gave at the Royal College of Physicians, 1861, that the pus corpuscle is not formed by the breaking up of the tissue, and the aggregation of lifeless particles resulting therefrom. Nor is pus produced by the precipitation of particles from a clear exudation and their subsequent aggregation to form masses, as Dr. Bennett of Edinburgh supposes. Pus, as I have endeavoured to show, is a form of living germinal matter, and has descended uninterruptedly from the normal germinal matter of the body. Virchow concluded that pus was formed in connective tissue corpuscles and in epithelial cells only. But there is little doubt that pus may be derived by very rapid growth from any germinal matter in the body.

The pus corpuscles usually figured and described are *dead*, not *living*. These spherical granular corpuscles have no longer the power of growth or multipli-

CHANGES IN INFLAMMATION—INCREASE AND MULTIPLICATION OF BIOPLASM.

Fig. 49.

Muscular fibres and connective tissue of the pectoral muscle of the frog in a state of inflammation from the immediate neighbourhood of the seat of injury FOUR days after the muscle had been transfixed by a fine thread. The vessels are seen to be filled with white blood corpuscles. Some of the bioplasm particles, probably derived from the white blood corpuscles (page 124) have escaped from the vessel at two points. The bioplasm of the connective tissue and also that of the muscular fibres is much increased. × 215. From a specimen mounted in 1863. p. 121.

$\frac{1}{1000}$ of an inch —— × 215 linear.

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cation. In many coagulation has taken place on the surface, and thus a sort of "cell wall" has been formed. Within this are granules and minute oil globules, resulting from the disintegration of the living matter, of which the corpuscle originally consisted, and germs of bacteria. Such pus corpuscles do not alter their form of their own accord. After a time they undergo further disintegration. If the pus remains in a cavity in the tissues, the fluid products may be absorbed, while a small quantity of cheesy matter, rich in oil and cholesterine is all that represents what was once pus.

But how different is the *living* corpuscle. This may be seen to change its form under the microscope. Diverticula, which are from time to time detached, are seen to be formed at every part of the circumference, and thus give rise to new pus-corpuscles. The living pus-corpuscle is a mass of living, growing germinal matter, derived from matter like itself, or from the normal bioplasm matter of the organism. Plate XV.

As I stated in 1863, the white blood corpuscle, the minute masses of germinal matter which I have described as existing in the blood, lymph corpuscles, chyle corpuscles, the masses of germinal matter in the spleen and other ductless glands, those found in connection with the walls of capillaries, germinal matter of nerve, muscle, and other tissues of the body, may give rise to pus if placed under conditions in which they are too freely supplied with pabulum.

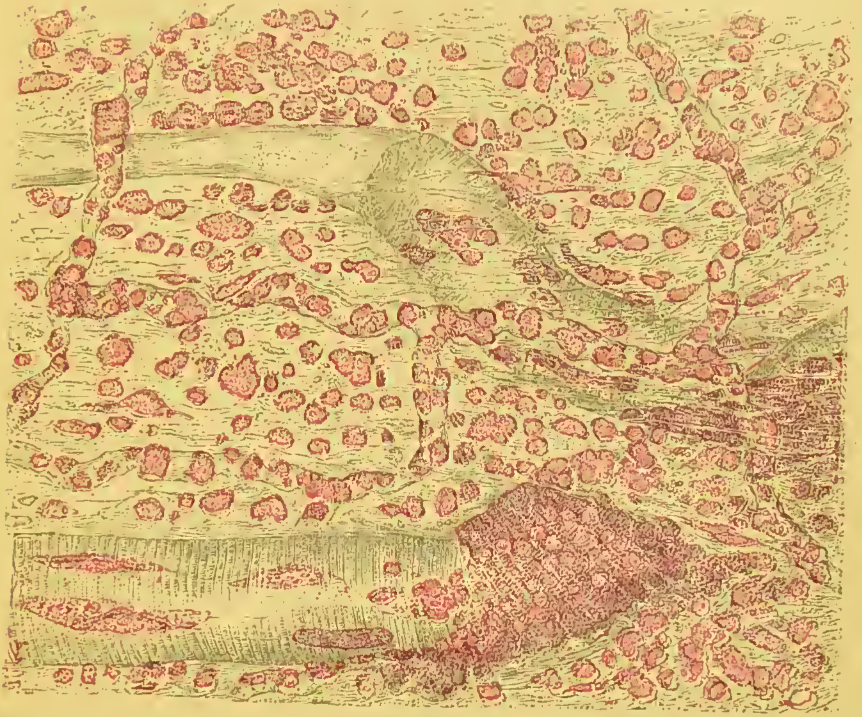
On the Movements occurring in ordinary living Pus.—I propose now to bring forward evidence which seems to me conclusive as to the mode of growth and multiplication of pus corpuscles, and which, I think, goes far to show how living particles, so minute that they may be transferred considerable distances without loss of vitality, may be produced.

There is certainly no true cell-wall in the case of living pus, for protrusions of the matter of which pus corpuscles consist may occur upon every part of the surface, and not only so, but some of these protruded portions, after moving a considerable distance away from the mass, become disconnected from it, and thus new pus corpuscles are produced. It is in this way that the very rapid multiplication of pus corpuscles is effected.

In pus from the bladder, movements even more active than those in the mucus corpuscle are very easily observed, and when fresh, not a single *spherical* corpuscle can be found. See Fig. 52, plate XV, representing some of the many different forms of pus corpuscles present in a very small quantity of pus. Every corpuscle exhibits a great number of these protrusions, and every protrusion might be detached and form a free pus corpuscle, Figs. 52, 53. Little particles are sometimes detached, and these are often so minute (less than $\frac{1}{100000}$ of an inch in diameter) that they might be supported by the atmosphere and thus transported to a distance while yet alive.

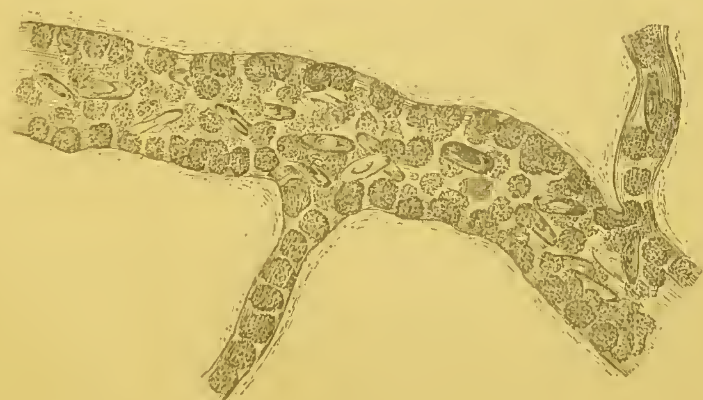
CHANGES IN INFLAMMATION—GREAT INCREASE AND MULTIPLICATION OF BIOPLASM.

Fig. 50.



This drawing was taken from a preparation resembling that represented in Fig. 49, but the period allowed to elapse after the inflammation had been excited was longer. The Frog was killed SEVEN days after the pectoral was perforated by a thread. × 215. p. 124.

Fig. 51.



[illegible] during life, a few minutes after inflammation had been excited by the application of mustard. × 215. p. 123

$\frac{1}{100}$th of an inch ———— × 40.
$\frac{1}{1000}$th ,, ,, ——— × 215.

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(Fig. 54.*) In warm weather, I have known the movements continue in pus corpuscles in urine containing little of the ordinary urinary constituents, for forty-eight hours or more after the urine had left the bladder.* The very phenomena which take place upon the surface of the mucous membrane of the bladder may in fact be watched for hours under the microscope, and there are few things more beautiful or more instructive.

The conditions required for the maintenance of life being more complex in the case of some forms of germinal matter than in others, we should conclude that such movements would continue for a considerable period of time in particles after their removal from their natural habitat, only in the lowest and most degraded forms. This is actually the case, just as some simple creatures are capable of supporting life under a great variety of conditions, while comparatively

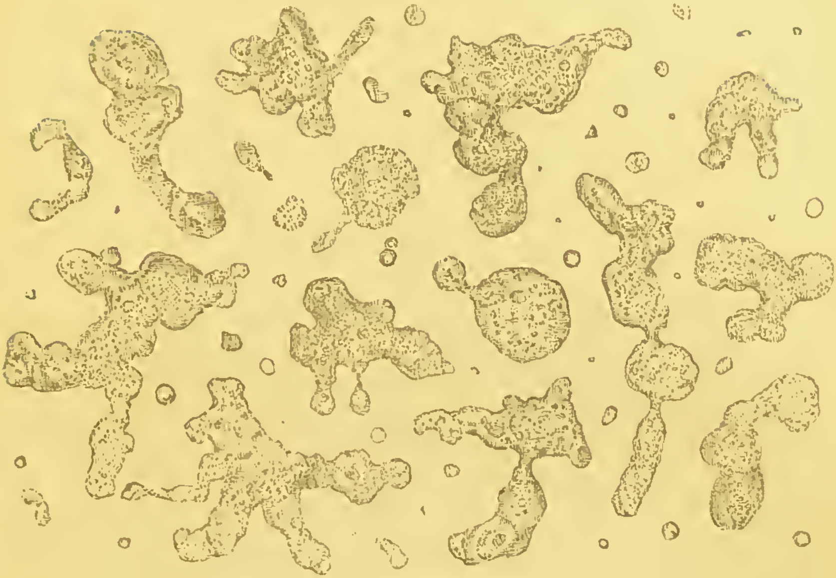
* It is probable that eareful observations upon this transparent living moving material will teach us mueh concerning the nature of life. I think that this subject merits far more attention than it has hitherto received, not only from physieists, chemists, and physiologists, but from philosophers. I do not think that what will be learned from the study will favour thc notions now most popular, but that is no reason why it should any longer be wholly neglected, espeeially by those who profess to desire to earry their enquiries to the utmost possible limits, but who really carry them a very little way, who, if sueeessful in dcstroying, are certainly obstructive. Some of those who profess to be most liberal in scicnec strongly object to cnquiry being carried beyond the limits thcy havc arbitrarily and without sufficient rcason laid down.

slight alterations would be fatal to others higher in the scale.

It is not possible to distinguish many pus corpuscles from lymph corpuscles, white blood corpuscles, and many other masses of germinal matter; indeed, if the developing brain of an embryo be examined at an early period, it will be found that this important structure consists of nothing more than a number of spherical cells, which could not, by any means we are yet acquainted with, be distinguished from many forms of pus corpuscles. See "The Microscope in Medicine," Plate XXIV, figs. 182, 183. If we carefully reflect upon many observed facts, we shall be compelled to admit that masses of germinal matter which resemble one another in every character we can ascertain, differ nevertheless remarkably in *power*, as is proved by the results of their living. Few recent writers seem to have fully recognized the remarkable truth that living things may agree in physical and chemical characters, but nevertheless differ widely in *power;* that transcendent difference in vital power may be associated even with similarity of composition, so that we are quite prepared for the discovery that the powers of certain forms of morbid bioplasm are very different from those of the normal living matter from which they have descended, although no difference whatever can be detected in their chemical composition.

Death and Decomposition of Pus.—When pus bio-

Fig. 52.



Pus bioplasts or corpuscles in active movement, from the urine of a case of chronic inflammation of the bladder. × 700. p. 128.

Fig. 53.

a. Portion of a living pus bioplast or corpuscle from the bladder. The portion marked *b* moved out in four seconds, and was then retracted. The other portion was extended in about the same time. × 2,800. p. 129.

Fig. 54.*

Different forms assumed by the same minute mass of bioplasm of pus from the bladder, during five seconds. × 2,800. p. 129.

Fig. 54.

A portion of a pus corpuscle from the bladder of man, the third day after the urine containing it had been passed. The ***vital movements*** had long ceased, and it was very transparent. At *a* little particles (Bacteria) were oscillating in all directions. One of these was seen to take the course indicated by the dotted line during the fraction of a second. × 2,800. p. 131.

$\frac{1}{1000}$ of an inch ———————— × 700.

$\frac{1}{10000}$ " " —— × 2800.

To face page 130

plasts die, and their death occurs when they are placed in any fluid which is not adapted for their nutrition, the vital movements cease and the corpuscles invariably assume the spherical form. Not unfrequently a change occurs in the outer part, and a sort of membrane like a cell wall is produced ; the contents become more granular, and they assume the appearance usually given in published drawings. After a short time the matter of which they are composed undergoes change, and is invaded by bacteria germs, which grow and multiply as represented in Plate XV, fig. 54. These bacteria are not formed directly from the matter of the pus which once lived, but it is quite possible that bacteria germs existed in a living but perfectly quiescent state amongst the oldest particles of the living matter on the surface of the pus corpuscle when it was yet alive.

DISEASE GERMS IN ANIMAL FLUIDS AND SECRETIONS.

BEFORE I proceed to describe the characters of the particles suspended in animal fluids, having virulent contagious properties, it is very desirable to draw attention to the minute particles of bioplasm, which may be demonstrated in many specimens of simple exudation. From this subject we shall pass on to the consideration of other forms of "exudation" which possess specific disease-producing properties. We shall find that by a careful microscopical examination of fluids which experience has proved to us have contagious properties, facts of great interest are disclosed which have an important bearing on the question of the nature of the poison of contagious diseases. Many such fluids are clear like water, and quite as transparent when examined by the unaided eye only. When we come to subject them to examination with the aid even of the highest powers yet made, although solid particles are detected, and sometimes in great number, we observe nothing peculiar to these fluids alone—nothing which would enable us to form any conception of the wonderful properties they possess—nothing that would attract the attention of the chance observer, or excite the interest of any one who had not long and carefully studied the matter. Nevertheless,

what we are able to demonstrate is of vast importance, and with the aid of other observations and experiments, we may form, I think, clear notions of the nature and origin of these morbid poisons, and of the manner in which they produce their marvellous and oftentimes disastrous effects. Much yet remains to be disclosed, but we shall soon learn more if we will but work and think independently, and accept the teaching of facts of observation and experiment, while careful to avoid being misled by the dogmatism of those who obstinately persist in asserting that all vital phenomena are to be explained by physics and chemistry, and try to make people believe that living organisms are mere machines constructed by force. For all truly vital phenomena must necessarily be altogether out of the range of mere physical investigation; nevertheless, to such extravagant lengths has the opposite view been carried of late, that it has even been seriously stated that he who refuses to look upon life as mere inorganic force opposes investigation, and looks upon the structure of man's organism as a subject unsuitable for scientific exploration. It would be as reasonable to assert that a man who is to be a scientific investigator must commence by confessing his belief in the truth of a conclusion which has long been proved to be false by reason and observation.

The evidence that the wonderful properties of the fluids about to be considered are due to the presence

of extremely minute particles of *living matter* will, I think, be admitted to be conclusive, while the effects produced by these in a living organism cannot be explained by physics or chemistry, or imitated artificially. Few persons will in these days be so deluded as to accept as an explanation the assertion that vital phenomena are "molecular," or admit that it conveys any more information than the announcement that the phenomena of living beings are due to the molecular changes in the basis of physical life. Such "explanations" explain nothing, and are but impertinent fictions of the imagination.

Simple Exudation.—The transparent colourless fluid which moistens the surface of a superficial wound after it has ceased to bleed, is poured out from the capillaries, or from the lymphatic vessels, or from both sets of vessels. This fluid, besides containing albumen in solution, contains multitudes of minute particles of bioplasm, which grow and multiply upon the surface. These form fibrin and matters more or less allied to it, and perform an essential part in the healing process, or in the formation of pus, as the case may be. These minute particles of living matter are present in the blood and lymph in countless numbers. They are concerned in the production of fibrous tissue outside the capillaries, which takes place in many pathological processes, and also in the production of pus-corpuscles, and other "corpuscles" in the same situation, in disease. All "exudations"

contain these particles of living matter. The following paragraphs are taken from a paper written by me in 1863* :—

"When the capillary vessels are distended, as in that extreme congestion which soon passes into inflammation, a fluid which possesses coagulable properties transudes through the stretched capillary walls. It is probable that in such cases minute and narrow fissures result, which, however, are too narrow to allow an ordinary white or red blood-corpuscle to escape, but, nevertheless, wide enough to permit many of the minute particles of the living or germinal matter (the existence of which in the blood has been already referred to) to pass through. The small protrusions upon the surface of the white blood-corpuscle might grow through the capillary walls, become detached, and pass into the tissue external to the vessels. Such minute particles of living matter external to the vessels being surrounded with nutrient pabulum, and stationary, would grow and multiply rapidly, while a similar change would of course go on in the now stagnant fluid in the interior of the capillary. The result would be exactly that which is observed, viz., the presence of a vast number of cells like white blood-corpuscles in the *interior of the capillary vessel, and immediately around its external*

* "On the Germinal Matter of the Blood, with remarks upon the Formation of Fibrin." Microscopical Society, December, 9th, 1863.—See Trans. Mic. Soc., April, 1864.

surface, and sometimes these extend for some distance in the substance of the surrounding tissue, and they increase in number.

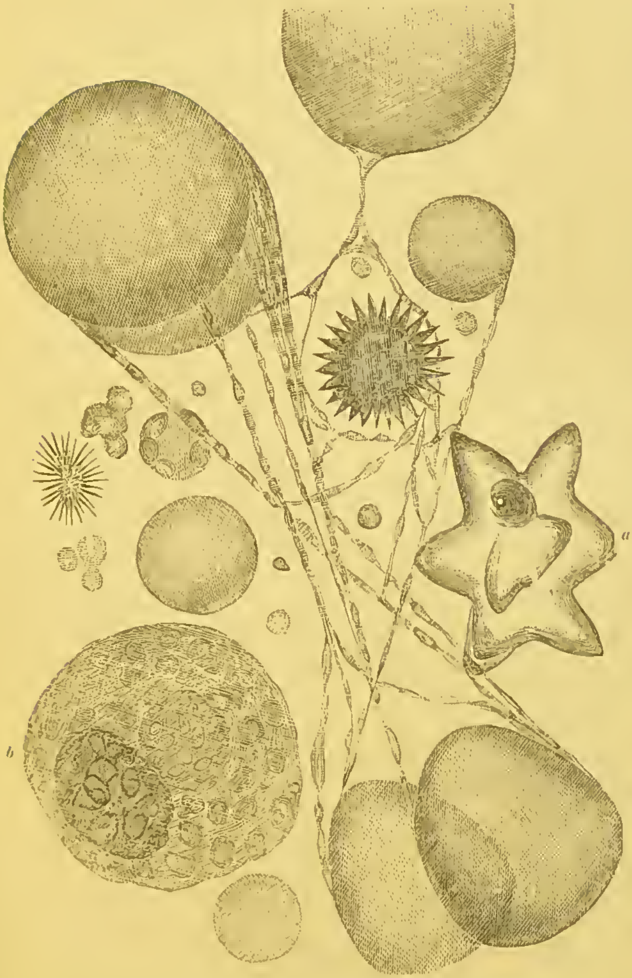
"I venture, then, to conclude that many of the clear fluids which have been considered as '*exudations*' from the blood, really contain a multitude of extremely minute particles of living matter, which are intimately related to the white blood-corpuscles, and that these grow and become one source of the small granular cells or corpuscles which are so familiar to all who have studied morbid changes in the tissues as they occur in man and the higher animals.

"Some of these active living particles may be so small as to be invisible by a power magnifying 5,000 diameters. I have seen such particles, less than the 50,000 of an inch in diameter, and have no reason whatever for assuming that these are really the smallest that exist."

These minute particles of bioplasm multiply freely, but they may also be derived from the white blood-corpuscles, and from other forms of bioplasm. The general appearance of such minute particles is represented in a minute portion of recently drawn blood in Fig. 55, plate XVI. As the blood coagulates they undergo change, die, and help to form the non-living fibrin. In every clot numerous white blood-corpuscles, also composed of living matter, can be detected, Fig. 57. In coagulation it is probable that the most minute particles of bioplasm change first, and become

LIVING BIOPLASM FROM THE BLOOD.

Fig. 55.



Red and white blood corpuscles in a drop of blood which had just been removed from the finger × 2,800 The large smooth circular bodies are the *red corpuscles*. Three very small red corpuscles are less than the $\frac{1}{8000}$th of an inch in diameter. The smallest particles are composed of matter like that of which the white blood corpuscle or blood bioplast (*b*) consists. Threads of fibrine are being formed by the coagulation of the minute particles of bioplasm of the blood. These are seen between the corpuscles in the upper and lower part of the field *a* red corpuscle exhibiting angular projections Above it and to the left is another with still more pointed processes September, 1863. p. 135.

Fig. 56.

Very minute particles of bioplasm from exudation. × 5,000. p. 136.

Fig. 57.

From a pale clot in the heart of a patient who died of exhaustion, showing white corpuscles, or blood bioplasts, and fibres of fibrine. × 700. p. 136.

Fig. 58.

Capillary vessel, from the mucous membrane of the epiglottis Showing numerous masses of bioplasm situated very close together and projecting into the cavity of the vessel. × 700. p 137.

$\frac{1}{15000}$th of an inch —— × 2,800.

[To face page 136.

fibrin. After a time the white blood-corpuscles also die, and thus the coagulum of fibrin continues to increase for a short time after coagulation has commenced. The diverticula from a white blood-corpuscle undergoing conversion into fibrin are represented in Plate XVII, fig. 60. The lines round the red blood-corpuscles seen stretching from one to the other in Fig. 55, represent the earliest stage in the formation of fibrin, and the minute particles of bioplasm are seen actually undergoing change. The bioplasm of the blood is derived from the bioplasm originally found in the vessels of the germinal area at a very early period of development, from the bioplasm of the capillary walls, which is very abundant in some capillaries, and projects into the cavity, Plate XVI, fig. 58, and from the lymph and chyle bioplasm which is being continually poured into the vascular system and mixed with the blood.

If the clear transparent material which moves round the cells of *Vallisneria* (Fig. 59, pl. XVII.) and other plants be carefully examined under very high powers magnifying upwards of 2,000 diameters, it will be discovered that this is not a simple fluid like water containing the nucleus and chlorophyl (Fig. 62). But the apparent fluid has suspended in it an infinite number of particles of living matter like those of which the amœba, white blood-corpuscle, and other forms of living matter consist. With high powers the slightly opalescent appearance may be detected, and

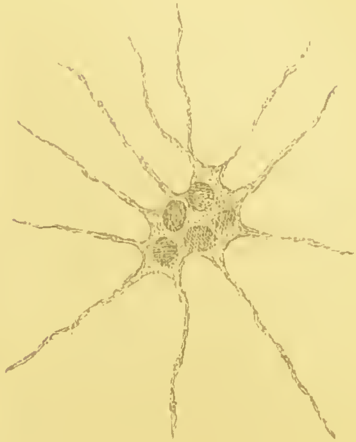
by careful foccussing minute particles of living matter will be brought into view. The movements of the fluid may therefore be compared with the movements of the living bioplasm of an amœba. In the circulating juice of many plants similar appearances may be observed, and in the blood and circulating fluid of all animals, and in man himself, minute particles of living matter are to be demonstrated in immense multitudes. These are diffused through the fluid, and to them is probably due the movement of the contents of the finer vessels and spaces. This constituent of the blood, seen with such difficulty that its presence is not yet admitted by observers, is probably the most important, for its increase or diminution may occasion serious disease or death. This almost impalpable living moving matter is the seat of many very important changes, and is perhaps influenced before any other constituents of the body when certain poisons and disease germs find their way into the blood. *Protection*, after successful vaccination, and the escape from a second attack, which is the rule in the case of many contagious fevers, is most likely brought about by changes induced in the living matter under consideration.

In health it is upon this material that the coagulable property of the blood is mainly dependent, and it is this which in great part undergoes conversion into what we call fibrin, when the blood is removed from the living vessels or "dies." If destroyed it may,

Fig. 59.

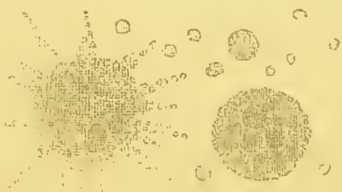
Vallisneria spiralis, showing large and small cells with living contents which rotate. × 130. p. 137.

Fig. 60.



Altered blood bioplast or corpuscle. Bodies of this form were common in the blood an hour after it had been drawn from the finger. The projecting processes consist of germinal matter which is gradually undergoing change into fibrin. × 1,800. p. 137.

Fig. 61.



Corpuscles consisting of germinal matter or living bioplasm in the 'lymph,' from a vaccine vesicle, showing changes in form which occurred a few minutes after the lymph had been transferred to a warm slide. × 1,800. pp. 144, 146.

Fig. 62.

Part of a cell in vallisneria, showing circulation. The large mass *a* with nucleus, is colourless, and consists of bioplasm. The smaller particles (under *b*) are also composed of living matter or bioplasm. The movements of the entire contents round the cell are probably due to these. After death they are transformed into form. The round bodies, *c*, are masses of chlorophyl, which are in process of formation. × 1800. pp. 137, 139.

$\frac{1}{10000}$ of an inch —— × 1800.

$\frac{1}{10000}$,, ,, —— × 2800.

under favourable circumstances, be renewed by the appropriation of nutrient matter by the white blood-corpuscles which are intimately related to this living bioplasm and take part in its formation. I believe they bear to it the same relation as the "nucleus" in the cell of Vallisneria bears to the living particles suspended in the fluid, Fig. 62, pl. XVII., while the red blood-corpuscles of the blood correspond to the chlorophyl particles in the rotating fluid contents of the vegetable cell. In this work attention will be drawn to the vast importance of this living fibrin-forming matter in various exudations, and it will be found that a simple explanation of many most important morbid phenomena may be given. Now in the fluid exudation or virus which produces a "poisoned wound" when inoculated we also find minute particles of living bioplasm.

Many arguments will be advanced in this treatise in favour of the view that the virulence of the poison is due entirely to the living particles, and not to the fluid in which these are suspended. In the case of some of these poisonous fluids we are able to study the production of the contagious virus, and we may even in some cases succeed in tracing out the manner in which the material with the wonderful poisonous property originates.

In some forms of inflammation of serous membranes the process may be made out, and a conception formed of the several changes which occur, and at

last end in the development of the poison. The morbid change is sometimes limited to the effusion of serum and the production of " inflammatory lymph," but in other instances the inflammation proceeds to a further stage, and actual pus is generated. Peritonitis is an example of an inflammation which much more frequently proceeds to the formation of pus than inflammation of other serous membranes. The greater vascularity of the peritoneum as compared with allied textures may perhaps account for this fact. It is interesting to discuss briefly the characters of the different "inflammatory products," as they are called, resulting from peritoneal inflammation, varying in intensity.

In *slight inflammation* there is great vascular distension, accompanied, as in other cases, by the escape of exudation in which are suspended particles of bioplasm. The exudation coagulates upon the surfaces of the serous membrane, perhaps glueing them together. The fluid portion is gradually absorbed, and if the case progresses to recovery, much of the coagulated matter is also taken up, a little being transformed into fibrous tissue, resulting in a few " adhesions," or mere thickening of the serous membrane, as the case may be.

When, however, the intensity of the inflammation is more marked, the little particles of bioplasm originally derived from the white blood-corpuscles, grow and multiply, and with the fibrinous matter in which they are entangled, form transparent flocculi, which

are suspended in the serous part of the exudation, or adhere here and there loosely to the peritoneal surface. Many of these flocculi are found to contain multitudes of bioplasm particles, and oftentimes a vast number of these are suspended in the fluid, and congregated here and there, forming little collections, upon the surface of the delicate serous membrane, to which they adhere, and where they grow.

If the inflammatory process still continues, and increases in severity, the vascular congestion becomes more marked, and the exudation is poured out from the blood more abundantly; the masses of bioplasm increase in number yet faster, and the exudation in consequence appears nearly opaque. The flocculi are of a yellowish colour, and look very like pieces of clotted cream which stick here and there to the peritoneum covering the intestines and the inner surface of the abdominal parietes. Not unfrequently the surface is smeared over in places with whitish pasty masses of soft cream-like matter, in the intervals between which the highly-injected vessels stand out with great distinctness. The masses of bioplasm would now be called *pus-corpuscles.* Here then is an interesting example of the production of pus-corpuscles by the rapid growth and multiplication of particles of bioplasm which were once in the blood, and intimately related to the white blood-corpuscles.

But further: if, as is well known, a little of this material were to be introduced into the body, as may

unfortunately happen from a dissection-wound in the course of making a post-mortem examination, terrible inflammation may be excited in the person inoculated. The most tiny morsel of this virulent, rapidly-multiplying morbid bioplasm may give rise to a dreadful form of " blood-poisoning," which may end fatally and in a very short time.

In some cases similar poisonous particles which have been derived from a diseased organism are so very light that they are supported by the air, and may find their way into the blood of a healthy (?) person through his respiratory organs, or may gain access to his circulating fluid by traversing the narrow chinks between the epithelial cells of the cuticle.

Now, what is the nature of the matter inoculated, which produces these dreadful results ? The virulent poison which sometimes destroys life in cases of dissection-wounds cannot, as was remarked in Part I, be attributed to the presence of vegetable germs, for the period of its most virulent activity is very soon after death, but before the occurrence of putrefaction, when the vegetable fungus germs multiply. A punctured wound is not dangerous if putrefactive decomposition has taken place, because, although bacteria are developed in immense numbers, *the real contagious virus is dead.* The vegetable germs in fact grow and flourish upon the products resulting from the death of the dangerous animal living poison. In short this material is living and very actively growing germinal

matter; living matter which retains its life after the death of the organism in which it was produced has occurred; living matter which has descended directly from the living matter of health, but which has acquired the property of retaining its life under new conditions; living matter destroyed with difficulty, and possessing such wonderful energy that it will grow and multiply when removed from the seat of its development and transferred to another situation, provided only it be supplied with suitable nutrient pabulum,—and it is to be feared the ordinary nutrient fluids of a perfectly healthy organism are eminently adapted for the nutrition of this destructive virus.

The Germs of Purulent Ophthalmia—Gonorrhœal Pus.—Such is the vitality of these forms of bioplasm that they will grow and multiply upon certain mucous surfaces if placed there; not only so, but the living particles will retain their vitality for some time after their removal from the surface upon which they grew. They may even be transported long distances by the air, or they may remain for some time in moist cloths without being destroyed. When once a room has been infected with such particles, some weeks may elapse before the death of all the specific disease-carrying germs has taken place.

The characters and *vital* movements of pus and minute pus germs, have been already described in p. 128.

The pus possessing specific contagious properties

cannot be distinguished from ordinary pus. It differs indeed from this last, but not in appearance, chemical composition, or physical properties. It differs in *vital power*.

Vaccine Lymph.—Vaccine lymph which has been just removed from the growing vesicle will be found to contain a great number of extremely minute particles of bioplasm, which may be well seen under a power magnifying from 1,000 to 2,000 diameters. In 1863 I made a drawing of the appearances I observed in the bioplasts from a drop of perfectly fresh lymph which had been transferred to a warm glass slide, and carefully covered with very thin glass, under the $\frac{1}{26}$ object glass, which magnifies about 1,800 diameters. The results are represented in Fig. 61, plate XVII, which was published in the "Quarterly Journal of Microscopical Science" for April, 1864.

In vaccine lymph which has been kept for some time in glass tubes, multitudes of very minute particles are observed, and these exhibit the most active molecular movements. These particles have often been termed *debris*, and have been regarded as quite unimportant elements of the lymph. To them, however, the active properties of the lymph are entirely and solely due. And I should be no more inclined, in the absence of the most positive evidence to the contrary, to regard the fluid portion of the vaccine lymph as the active material, than I should be to assume that the fluid in which the spermatozoa were

suspended was the fertilizing agent, and that the spermatozoa themselves were merely epithelial *débris*, and quite unimportant; or to infer that the fluid in which the yeast fungi or bacteria were growing, was the active agent in exciting fermentation while the actually growing, moving and multiplying particles were perfectly passive. The germinal particles in all cases are, without doubt, the active agents, and it seems to me as much opposed to the facts of the case to maintain that the *materies morbi* of cattle plague and other contagious fevers is a material that can be dissolved in fluid, and precipitated and reformed, or sublimed as a volatile substance, as it would be to look upon any living organism as the result of the concentration of an albuminous solution, and capable of resolution and precipitation.

The little particles represented in Plate XVIII, fig. 66, could not be distinguished from the minute particles of pus, Plate XV, fig. 54*, or other germs of living germinal matter, and I think they consist of a peculiar kind of living matter, the smallest particle of which, when supplied with its proper pabulum, will grow and multiply, giving rise to millions of little particles like itself, each having similar properties and powers.

I consider it to be almost certain that the material of which these particles are composed has the power of forming matter like itself from pabulum around it, which differs from it in properties and composition.

Such living germs may pass from the organism on which they grew to another, and will grow and multiply there if they meet with the proper pabulum. The only condition in which matter is known to exhibit these powers of self-multiplication is the living state.

M. Chauveau (Comptes rendus, February, 1868) described these same bodies in 1868. It is evident he had not seen my observations, published in the Cattle Plague Report, or my previous researches published in the Microscopical Transactions for 1863.* Fig. 61, plate XVII, was appended to this paper, which was read December 9th, 1863. Chauveau showed that the active particles subsided after forty-eight hours, and that no effects were produced by inoculating the albuminous supernatant fluid, while the full effects were produced by vaccinating with the deposit. As would be supposed from the excessive minuteness of these bodies, they are not to be separated by ordinary filtration, but if the fluid containing them also contains a trace of coagulable fibrin diffused through it, this by contraction after coagulation would filter off the little bioplasts, and leave a serum perfectly free. Dr. Farr calls the living particles *biads* (*βια*, force, *βιος*, life), and speaks of the vaccine particles as

* "Beale had, before Chauveau, declared that the 'active properties of vaccine lymph are entirely and solely due' to these corpuscles. He has figured them."—Dr. Farr, "Report on the Cholera Epidemic of 1866," p. lxviii.

vaccinads.—"Report on the Cholera Epidemic of 1866," p. lxx.

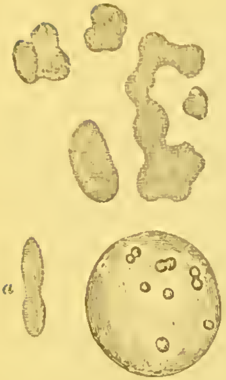
The circumstance that vaccine lymph retains its activity if kept in a tube for several weeks, seems conclusive as to the possibility of the particles retaining their vitality for a considerable time after they have been removed from the place where they grew; the arguments advanced as proving that the active power resides in the particles and not in the fluid, being admitted. It is not more difficult to explain the fact that such living particles may be dried without losing their power, than that an amœba or rotifer should exhibit the same peculiarity. As this property is observed in connection with many of the lower forms of life, we might almost anticipate that the living matter from the highest organisms, if reduced to a degraded condition, would retain its vitality under circumstances which would cause its death in its normal condition. Yet it must not be supposed that these particles any more than the "dried animalcules" are really dried. Some moisture is retained by the particles within the imperfectly dried mass. Complete desiccation will destroy life in both cases. Since it has been shown that the active powers of vaccine lymph reside in the minute particles of living germinal matter, and it has been proved that these may be dried (imperfectly) without loss of power, it is surely not too much to conclude that the *materies morbi* of other and allied contagious diseases is probably com-

posed of living particles which have the same property of living for some time in a state of partial desiccation.

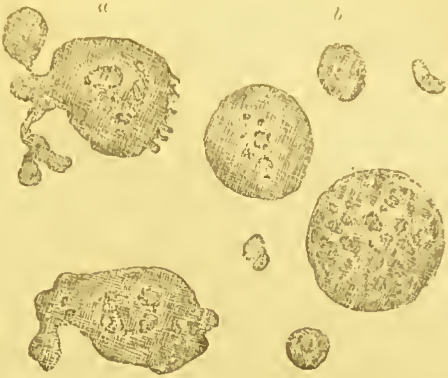
Living Germs of Variola.—I have examined the contents of the little vesicle which rises in small-pox at different stages of its development, and find, as in allied pathological changes, vast multitudes of minute particles of living matter or bioplasm, but, as will have been anticipated from what has been already said, these present nothing peculiar or characteristic, nothing that would enable us to say if we saw these particles under the microscope that they had been obtained from a small-pox vesicle, and would certainly give rise to that disease. I have made a drawing of some of the varioloid bioplasts from a well-developed vesicle on the fifth day of the disease, and also from a vesicle which was just making its appearance. Plate XVIII., fig. 64.

Living Germs of Fever.—As was shown experimentally of Dr. Sanderson, a mere trace of blood *serum* was sufficient to propagate cattle plague. A very small portion of blood or of the tissues of an infected animal had the same effect. Nay, the contagium is so subtle that in this as well as in many other contagious diseases, the breath of the diseased organism contains numbers of the potent particles of poison, and in this manner the very air of a considerable space or even district may become infected.

Fig. 63.

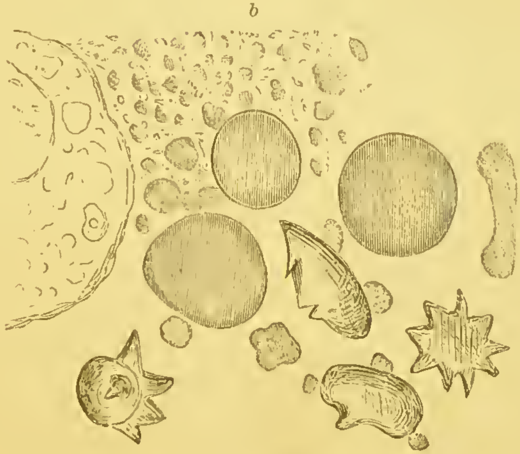


Bioplasts from the vaginal mucus of a cow. Cattle Plague, *a*. bacterium amongst these. *b*. a mass of germinal matter containing minute particles like bacteria. These are also seen in the white blood and pus corpuscle, &c. × 2,800. p. 148



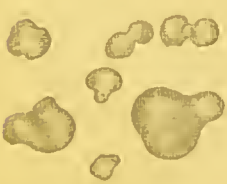
Bioplasts from small pox vesicles on the fifth day of the disease The two bodies under *a* from one of the youngest vesicles, which was just beginning to be white at the summit. The six bodies under *b* from a fully formed vesicle × 1,800. p. 148

Fig. 65.



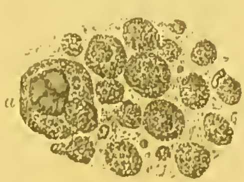
Blood from intestinal capillaries and small mesenteric vein Cattle Plague. The serum was reddish *a*. part of white blood corpuscle in outline; *b*. minute particles of bioplasm (disease germs) in immense number in all parts of the field The smooth round bodies are young red corpuscles. The angular corpuscles are old and altered red blood corpuscles × 2,800. p 149

Fig. 66.



Particles from vaccine lymph which had been kept in a tube, exhibiting very active movements. × 5,000. pp 141, 115.

Fig. 67.



Very small masses of germinal matter and white blood corpuscle (*a*) from small vein as in Fig. 38. × 2,800. p. 149

Fig 68.

White and red blood corpuscles from a branch of the pulmonary vein. Cattle Plague. A quantity of germinal matter or bioplasm in a very minute state of division is seen around the lower part of the white corpuscle. × 1,800. p 149.

$\frac{1}{10000}$ of an inch —— × 1600.

,, ,, ,, —— × [illegible]

In the blood removed from the smaller vessels, in the mucus secretions of the mouth, intestinal canal, and in the milk of animals suffering from this disorder, I have found multitudes of minute particles of bioplasm, which, as long as they remain alive, are, without doubt, disease-carrying particles. Disease germs are figured in Plates XVIII and XIX, and in Plates XXIV to XXVII. Their characters will be further discussed in the Section on the "Nature of Disease Germs," p. 161.

The disease germs of many contagious fevers will retain their vitality in water and other fluids for a length of time, and there is reason for concluding that some of these poisons not only grow and multiply in fluids different from any in the organism, but that in the course of such growth and multiplication, they acquire still more virulent properties. Dr. C. Macnamara has discovered that cholera poison in water after exposure to the sun for a few hours, becomes extremely virulent, and that this period corresponds with the development of multitudes of vibrios; but that after the lapse of a day or two, when the vibrios will have disappeared and given place to ciliated animalcules, the fluid may be taken with impunity.

Syphilitic Disease Germs.—The syphilitic germ is another of those remarkably special living poisons which may be suspended in serum and other fluids, and retain its vitality for a length of time.

There is reason for thinking that a single epithelial cell may carry multitudes of active particles of syphilitic poison, one of which introduced into the blood or lymph of a healthy person would probably grow and multiply, and give rise to pathological changes characteristic of, and quite peculiar to this particular poison.

We know that the syphilitic poison may retain its specific characters in the organism for years, from time to time giving rise to local pathological phenomena, which are characteristic of this kind of morbid bioplasm. It is impossible from the facts of the case to arrive at any other conclusion than this : that a certain portion of the living matter remains in the organism, and that under certain favourable circumstances this grows and multiplies, producing disease. Particles of this virulent poison may be transferred from the infected organism to a healthy one, and contaminate it, even many years after its introduction into the first had taken place. Of syphilitic bioplasm there are different kinds, giving rise to different pathological affections belonging to the syphilitic class. Indeed, some facts render it probable that there are several different species or varieties of syphilitic poison, instead of only one or two.

One very remarkable property of the poison of syphilis is, that it may be re-inoculated into the same organism over and over again, until inoculation ceases to produce any specific effect. As soon as this is the

case, the organism is said to be "protected." But such protection sometimes cannot be procured until successive inoculations have been practised during several months, and, as has been remarked, the remedy is in many respects worse than the disease, besides being, and on many grounds, quite unjustifiable.

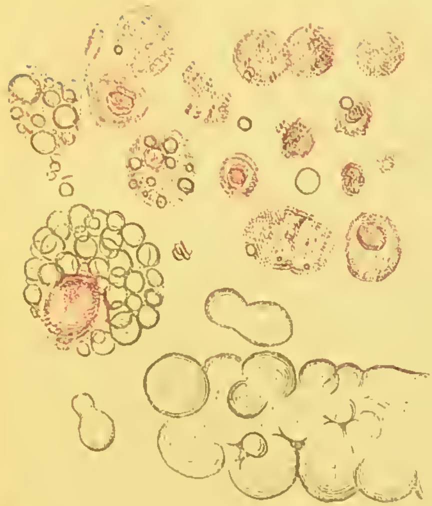
Living Disease Germs in Secretions.—The living germs of many fevers pass from the blood into the secretions. The urine, the secretions from the mucous membrane of the nose, mouth, stomach, and intestinal canal, contain them in large numbers. There is reason to think they may also escape in the secretion of the sweat and sebaceous glands. In the excrements there can be no doubt disease germs exist in vast numbers in typhoid fever, in cholera, and in some other diseases. Even in the milk, in the tears, in the saliva, they are present. Some of the living particles in the milk from a cow suffering from Cattle Plague are represented in Figs. 69 and 71, plate XIX, and in Fig. 70, particles of bioplasm as well as fungi are seen in vaginal mucus from another animal suffering from the same disease. The particles of bioplasm in which I believe the contagious properties reside, are situated immediately under the letter *d* in Fig. 70. Below and to the left of these particles are sporules of fungi, which cannot be mistaken. Their spherical form, sharp, well-defined outline, and the high refractive power of the envelope, positively distinguish them from disease germs.

M 2

Living tubercle germs will not be considered as very closely related to the contagious particles which are the active agents in the propagation of contagious fevers. There is, however, reason to think that particles of living growing tubercle exist sufficiently minute to be supported by the atmosphere and carried long distances ; while there are many facts which are considered by some sufficiently conclusive to justify the opinion that tubercular disease of the lungs is at least in some instances *contagious.* And it is certain that the most recent observations in connection with the question of the nature and mode of propagation of tubercle, so far from militating against this view, tend rather to support it. That tubercle is not eminently contagious is certain, while the probabilities of minute particles of living growing tubercle escaping into the air while it remains in the air-cells of the lungs, or rising in a living state into the atmosphere from the sputum after its expectoration, are not great. At the same time neither circumstance can be regarded as impossible, neither view can be held to be untenable.

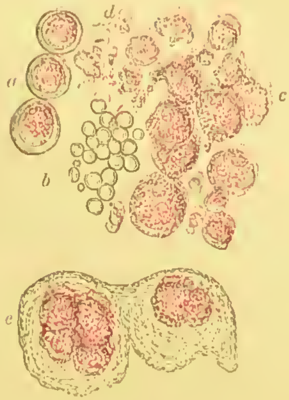
The manner in which the bioplasm of tubercle multiplies is represented in Fig. 73, pl. XIX, where it is seen extending round a small artery in the areolar tissue of the external coat. The living particles obstructed in the vessel make their way through its lining membrane and between the fibres of the muscular coat, until they reach the areolar tissue

Fig. 69.



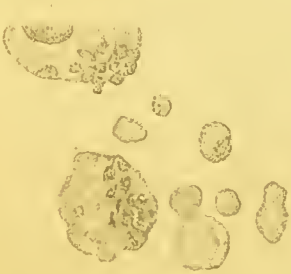
..ilk. *a*. Colostrum corpuscle with bioplasm; *b*, ..al.. matter forming cylindrical masses; *c*. growing germinal matter or bioplasm, the so-called puslike corpuscles in the milk of a cow suffering from cattle plague. × 700. p. 151.

Fig. 70.



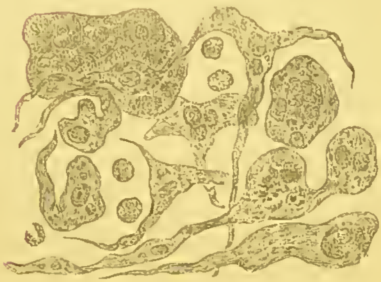
Mucus from vagina. Cattle plague. Bioplasm growing and multiplying rapidly. *a*. Sporules of fungi; *b*. small sporules of fungi; *c*. corpuscles and pus-like cells. The manner in which the rapid multiplication of imperfectly formed epithelial cells takes place is represented at *e*. Observe the concentric layers of the imperfectly hardened formed material. × 700. p. 151.

Fig. 71.



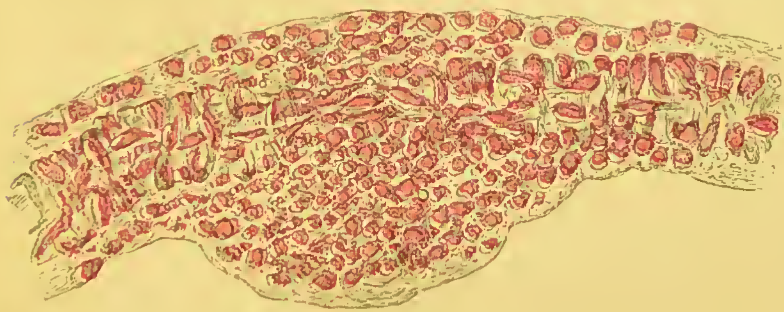
..me.. the smallest masses of bioplasm (not coloured) in milk in cattle plague × 2,800. p. 151.

Fig. 72.



Bioplasm (not coloured) in cancer cells from a case of cancer of the bladder. × 215. p. 151.

Fig. 73.



..ubercle bioplasm in the coats of a small artery of the pia mater, from a case of tubercular inflammation. Death three weeks after the commencement of the attack. × 215. p 15..

$\frac{1}{1000}$ of an inch —— × 215.

" " " —— × 700.

$\frac{1}{10000}$ " " —— × 2800.

[To face page 15..]

outside, where they grow and multiply. By their accumulation, the pressure upon the vessel becomes greater, and at last its calibre will be completely obliterated. From such tubercle collections minute bioplasts may be readily detached, and after having found their way into a pervious lymphatic vessel, or blood capillary, might be carried to distant parts and grow there. In this way tubercles are developed in many different parts of the body and in the substance of many different tissues and organs. If a particle of fluid, holding living tubercle-germs in suspension, were introduced by inoculation into a weakly organism, the disease might be produced.

Cancer Germs.—Whilst it is almost certain cancer could be introduced by direct inoculation into the organism of a healthy person, many circumstances render it in the highest degree improbable that living germs detached from the growth, could, under any circumstances, gain access to another organism through the air breathed, or in any other manner pass into the blood or tissues, as long as the surface remained uninjured. Cancer germs would probably live for some time in animal fluids out of the body, and it is by no means impossible that we may succeed in growing them in glass vessels away from their natural seat of growth, and watch the changes which occur under our microscopes ; but it is exceedingly doubtful if these germs would long retain their vitality if removed from the fluid which nourished them. Some

cancer germs are represented amongst the large cancer cells figured in Plate X, fig. 44, and in Plate XIX, fig. 72. Between the cancer germ, which cannot be conveyed by the air from the diseased organism to one not infected,—and the germ of scarlatina, which will retain its vitality for weeks after it has escaped from the organism in which it was produced, and may readily gain access to healthy organisms in the air they breathe,—we have examples of living disease germs manifesting powers of retaining their vitality when free in many different degrees. In other words, these poisons differ remarkably in the facility with which they are propagated, or spread from person to person. All exhibit the same appearances, though they differ remarkably in power. The capacity for resisting death, due to some inherent power and not to their chemical composition, varies much, some being capable of living for weeks or months away from the fluids of the body, while others die within a very short time of their removal from the seat of growth.

In this section a number of remarkable forms of contagious matter or virus have been referred to. These resemble one another in general appearance. Neither by its form, chemical composition, or other demonstrable properties, could the vaccine germ be distinguished from the small-pox germ, or the pus-germ from either. All are like the minute particles

of bioplasm of the blood from which they differ so remarkably in power. Of the conditions under which these germs are produced, and of the manner in which the rapidly-multiplying matter acquires its new and marvellous specific powers, we have very much yet to learn. Those who have committed themselves to physical views of life, undisturbed by the signal failure of all their attempts to demonstrate facts in favour of their hypothesis, must needs resort to the wretched expedient of suggesting that differences of *form*, *structure*, and *composition*, *may be* discovered at some future time. These, when discovered, they prophecy will fully account for the marvellous differences in power manifested by the different kinds of formless, structureless, living matter, healthy and morbid, which has hitherto defied chemical analysis. Yet it is imagined that the difference between the chemistry of the small-pox germ, and that of the ordinary pus germ, will be found sufficient to fully account for the different actions of the two. When chemical science shall have progressed sufficiently to enable chemistry to demonstrate the highly complex chemical phenomena of these germs, their marvellous collocations and combinations will, doubtless, be exhibited to the public. In the meantime chemists and physicists await with confidence the fulfilment of their prophecies, and decline to take notice of any facts that have been, or that may be advanced, against their untenable doctrines.

INTRODUCTION OF DISEASE GERMS INTO THE BODY AND OF THEIR ESCAPE.

Disease Germs in Air, Water, and Food.—Such minute particles as those described in the last section are liable to be suspended in the air we breathe, or they may be disseminated through the water we drink, or hidden in the food we eat. Not only so, but there is reason to think that some kinds of these contagious disease germs even grow and multiply outside the body. Indeed, it appears probable that a few actually acquire their virulent properties after they have left the organism in which they have been developed, while they remain immersed in some extraneous medium containing the proper elements for their nutrition and further development.

That such particles as those represented are sufficiently light to be supported in the air and carried long distances by air currents, is proved by the fact that the scales of the wings of insects and starch corpuscles, each of which weighs more than a hundred times as much, are supported by the slight currents of air in our ordinary rooms, deposited upon shelves, and even transported long distances. The careful examination of the particles suspended in the air as seen in a sunbeam, renders all further remarks upon this part of the question superfluous.

It is well known that many contagious diseases may be propagated by the breath. Of this we have direct proof as regards the poison of cattle plague, small-pox, scarlet fever, and some others. Küchenmeister made a sheep breathe, during one hour, air which was made to traverse the shirt worn for twelve hours by a patient who was suffering from small-pox. Five days afterwards the disease commenced, and by the eighth day a well-marked eruption of variola was developed upon the sheep. Glanders is another contagious disease, and of a most fatal kind, which is propagated through the air, and, although direct inoculation is usually necessary for its communication to man, in one case which fell under my observation, the evidence that the fatal disease was communicated by the air was very strong indeed, if not perfectly conclusive.

I have endeavoured to ascertain if such particles as I have described could be actually demonstrated by microscopical investigation with the aid of the highest powers, in the air which was known to contain a form of contagious poison. Mr. Crookes made some investigations upon this part of the subject in connection with the Cattle Plague Inquiry, and he obtained some very interesting and important experimental results. He was good enough to give me a tube which contained a piece of cotton wool that had been exposed to the breath of a diseased animal, and was fully impregnated with contagious

matter, and another tube through which the breath of an animal, dying from the disease, had been passed. I carefully moistened the wool and the tube with perfectly pure glycerine, and subjected the fluid to examination with the $\frac{1}{50}$th.

Although in each case I have seen particles resembling those already many times referred to, I do not attach much importance to these two isolated observations, or look upon them as conclusive, for in the first place the number of minute particles of various kinds present makes it impossible to identify with any certainty the supposed particles of *contagium;* secondly, as there are undoubted sporules of fungi, I could not prove that the very minute particles which I should be inclined to regard as the *contagium* had not been developed from these; and, thirdly, in such an enquiry it would be wrong in principle to place much reliance upon only one or two observations.

At the same time it is only right to state that the piece of wool in one of the tubes, through which the breath had been passed, exhibited a much greater number of minute particles, resembling those which I regard as particles of contagium, than were obtained from the second piece of wool at the other end of the same tube, by which the air was subjected to a second filtration. It does, therefore, appear *possible* to determine the question from this experimental side. The microscopical part of the investigation presents

many practical difficulties, and any one entering upon it should perform, in the first instance, a great many preliminary experiments in order to determine the most convenient and most delicate methods of examination.

Many disease germs will retain their vitality in water, and there can be no doubt that many are introduced into the organism in this medium only. From the evidence that has been adduced, it is certain that both typhoid fever and cholera are disseminated by drinking water, and almost as certain that if pure wholesome water had been supplied to the victims instead of the disease-carrying fluid, many lives would have been saved. That some disease germs will live for a considerable time in water, may be proved by experiment. Pus-corpuscles from the bladder may be kept alive in water, to which a very little albumen or serum has been added. The gonorrhœal poison-germ, as well as the bioplast capable of producing purulent ophthalmia, will also retain their vitality in water, and probably even in water containing soap and other things dissolved in it. Much of the water containing disease-producing germs is very rich in organic matter, and the products of the decomposition of organic matter. Hence it is *always* desirable to discard such water for drinking or culinary purposes. Although there can be no doubt that many bad specimens of water are perfectly harmless, as we are unable to say whether disease germs are actually

present or not in any given specimen, the only safe course is to condemn all water rich in dissolved and suspended organic matter, and to subject all doubtful specimens to the action of Condy's fluid, boiling and filtration, before its use is permitted.

Various kinds of food afford a nidus for disease germs. Articles of diet should never be kept in the sick room longer than necessary, and the healthy should never be permitted to partake of food which had been left for some time exposed to the air of the sick room. In milk and weak soup it is probable some disease germs might retain their vitality for a length of time, and perhaps in warm weather grow and multiply to a great extent; and although a number of persons might perhaps take these fluids with impunity, or be in other ways exposed to the influence of disease germs, the probability that but one here and there would be attacked, renders the slightest carelessness on the part of the attendants highly culpable, and deserving of severe punishment.

As is well known, the poison of scarlet fever, small-pox, and some other contagious diseases, may be retained for a length of time, in a living state, in the clothes of the sick, in the bedding, hangings, furniture, on the paper of the walls, and even in the floor, of the sick room. It is probable that in these cases the living germs are embedded in a portion of the poisonous matter itself or the secretion in which it

was present, or in some other kind of organic matter which has dried up. Thus some of the germs become protected in the same manner as the living germs of vaccinia and of variola are preserved in the partially dried lymph. In this way, as is well known, they will retain their vitality even for many weeks upon the point of a lancet or upon a glass or ivory plate.

On Detecting Disease Germs in the Air.—Various methods for detecting germs in the air have already been referred to when the subject of vegetable germs was under consideration. It remains now only to describe the apparatus recently devised by Dr. Maddox, for collecting from the atmosphere all foreign particles suspended in it. A full account of the instrument in question is given in the "Monthly Microscopical Journal" for June 1st, 1870, p. 286. The arrangement will be understood, if the figures in Plate XX, copied from those illustrating Dr. Maddox's paper, be referred to.

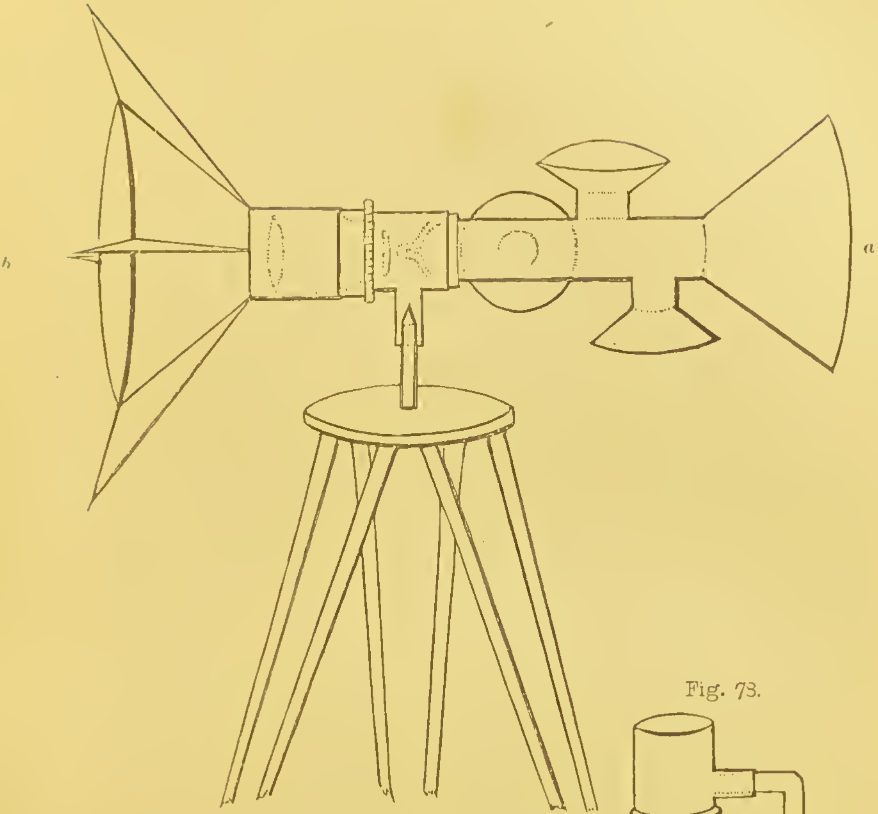
In Fig. 74, the instrument is so placed as to be used like a vane outside the house. By slipping off the vane, and placing the rest of the apparatus in a vertical instead of horizontal position, and attaching to it another short tube (Fig. 78) with a metal pipe terminating in a small funnel, it can be used over a cesspool, in any nook or corner, in an ordinary room, in a cow-shed or stable, or in a ward near a patient suffering from any infectious disease. A draught of

air is produced by placing a lighted lamp under the funnel, as shown in the drawing.

When the apparatus is to be used vertically, the extra brass tube (Fig. 78) is to be slipped over the end, and the whole is to be supported by one of the retort-holders of the laboratory, or in any convenient way, and beneath the open end of the little funnel is to be placed a lighted oil or spirit lamp, in order that a current of air may be generated. Its position above the surface of the ground may vary from a few to many inches or feet, according to choice. Dr. Maddox thinks about 3 feet the proper height. If it be desired to test the efficacy of various vapours or fluids as disinfectants for the purpose of destroying the living germs, an extra nozzle (Fig. 77) made as a flat box having a small nozzle projecting from the cover, looking towards the thin glass, can be screwed on the ordinary one. "If this narrow box, which should be platinized inside, be packed with fine cotton wool, damped at one part with any article, as creosote, tincture of the muriate of iron, or solution of quinine, or a particle of hypochlorite of lime placed at one part, the particles from the air may be supposed to be entrapped amongst the fibres; but the cotton-wool should, before use, be soaked in absolute alcohol for half an hour, and squeezed dry between heated plates of glass; or gun-cotton might be used if thought more free from error. The wool from opposite the nozzle might, in each case, be

DR. MADDOX'S GERM COLLECTING APPARATUS.

Fig. 74.



[illegible] Maddox's apparatus for collecting germs and solid particles suspended in the atmosphere The air enters at *a* and through the smaller funnels above and below, it passes through the narrow nozzle in the central part of the figure and strikes against the thin glass placed immediately beneath This is smeared with glycerine or purified treacle and to it all foreign particles adhere. The air then escapes through some holes at the circumference of the glass and then passes away. p. 161.

Fig. 78.

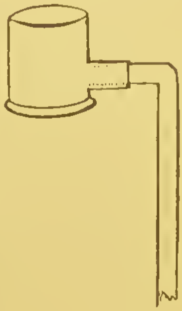


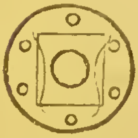
Fig. 75.

The spring for retaining the thin glass in position, seen in section

Fig. 77.

Screwed pipe with fine extra nozzle for experiments with disinfectants. p 162.

Fig. 76.



The thin glass on its plate with holes around the circumference, through which the air escapes.

Tube and lamp for causing a draught through the apparatus when it is used in a room or confined space. The vane is removed and the apparatus arranged vertically. p. 162.

removed with a pair of fine scissors and forceps, placed in a deep growing slide with some medium, and set aside for observation."

The advantages claimed by Dr. Maddox for this apparatus are ready application at any spot, the collection of the atmospheric particles *into a small space* in such a manner that they may be at once microscopically examined with a $\frac{1}{16}$th or $\frac{1}{20}$th objective, placed in some form of cultivating apparatus for further observation, or mounted permanently.

Dr. Maddox has found besides particles of various organic and mineral matters, pollen grains, minute germs of various fungi or protophytes, and excessively minute bodies, "molecules," "globules," &c. These varied in number according to the force of the wind, dryness of the ground, and other circumstances.

At the close of his paper Dr. Maddox remarks:— "The examination of the collections made over forty days has shown that in this immediate locality (Woolstone, near Southampton), at this period (May), the air cannot be considered as *loaded* with microscopic germs; the largest number visible and counted as such on one cover being twenty-one (not including bacteroid bodies). A few only have germinated; they are under observation."

Mode of entrance of Disease Germs.

Of the Passage of the Disease Germs into the Blood.—In all cases in which disease germs produce their characteristic effects, they reach the blood. Until they have entered this fluid there is no possibility of their exerting any deleterious effects upon the system. Having entered the blood, they grow and multiply, and, as we shall see presently, become obstructed in the smaller capillary vessels, in and around which those changes occur, which give to each particular contagious fever the characteristics peculiar to it, and enable us to recognize and define it.

With regard to the manner in which the minute particles of contagious germinal matter gain access to the blood, there has been much difference of opinion, but many circumstances render it certain that they may reach it from many different surfaces.

Suspended in the air, they may pass towards or into the air-cells of the lung at every inspiration. Some of the lightest particles might reach the ultimate air-cells where an exceedingly delicate membrane easily penetrated by living particles alone separates them from the blood.

If living disease-germs fell upon the soft mucous lining of the air passages, they would there find a material if not adapted for their nutrition, at least favourable for preserving them in a living state. Through this they would gradually make their way

into the capillary vessels or lymphatics, ramifying in the tissues beneath. But besides gaining access to the blood of man's organism through the breathing apparatus, the particles of contagious germinal matter may pass into the stomach with the food, and make their way into the blood after traversing the delicate mucous covering of that organ. They might get into some of the mucous follicles, and after growing and multiplying there, some of the particles might reach the vessels which lie just beneath.

As has been already mentioned, some disease-germs, like the lower vegetable and animal organisms, will live for a considerable time in water. But it must not be concluded that this fact tends in any way to favour the view that disease-germs are in fact animal or vegetable particles, for pus-corpuscles will not only live for a considerable period of time in water, holding in solution a very small quantity of animal matter, but they will grow and multiply. Of all media *taking part* in the wide diffusion of disease-germs, and facilitating their introduction into man's organism, water, there is reason to think, is the most general, and, perhaps with the exception of air, the most effective.

Lastly, the particles of contagious bioplasm or germinal matter may enter the body through the skin. In some states of the cutaneous surface, the epidermis is swollen, softened, and moist, and living particles would easily insinuate themselves in the

slight chinks which exist between the epithelial cells, and gradually make their way into the capillary vessels beneath.

I have heard that a well-known physicist has said, that if his mouth and nose were protected by a cotton-wool respirator, he would not hesitate to sleep in a bed which had been occupied by a patient suffering from scarlatina. Although we are much in want of information concerning the precise mode of ingress of poison-germs, I trust that so foolish and utterly useless an experiment will not be made. If the experimenter took the disease, the fact would add nothing whatever to our knowledge, while if he escaped scathless, the fact could be more satisfactorily explained than by attributing it to the efficiency of the vaunted cotton-wool respirator. Germs so minute as those of contagious diseases will find their way into the blood by other channels than the air passages or alimentary canal. The mucous membrane of the conjunctiva, covering the front of the eye, is soft and moist, and they could easily worm their way between the soft epithelial-cells, and thus reach the blood. They might readily make their way into a hair-follicle, or pass down the tube of a sweat-gland. There are also many passages opening upon the external surface of the body by which such minute living, moving particles might gain access to the moist tissues, and make their way into the blood

In some instances it seems that the disease-germs gain access to lymphatic vessels, and grow and multiply there, causing abscess in some of the lymphatic glands. The blood is sometimes infected as well, while in some cases, in which there is serious inflammation of lymphatic glands, it appears to escape contamination.

The living particles of contagious germinal matter readily find their way into the blood if there is an open wound upon any part of the body, and if, as is not unfrequently the case in patients suffering from wounds, the blood is not in a healthy state, the poison grows and multiplies rapidly. To introduce cases of contagious fever into a ward where a number of persons who have undergone surgical operations are lying, would be a cruel and, though not so in law, a criminal act. To place a surgical case in a medical ward in which fever cases of any kind are admitted, is most dangerous. Even slight wounds like those made in operations upon the eye do not heal readily, and out of a number of such cases a large percentage will certainly go wrong. Accoucheurs are well aware of the horrible fatality of contagious poisons when introduced among lying-in women, and are but too often painfully familiar with the dread certainty with which these minute germs make their way into the blood, poison the living matter of the body, and destroy life in the puerperal state. For this reason lying-in wards can never be maintained in any general

hospital, if cases of disease depending upon contagious poisons are also admitted. It is probable that if cases of surgical operations were placed in buildings apart from medical cases, the mortality from pyæmia and allied diseases, would be considerably reduced.

State of Vessels favouring the Entrance of Disease-germs.—Admitting, then, that it has been proved that contagious poisons generally consist of minute particles of living matter or bioplasm, and that this living matter, to produce its characteristic effects upon the system, must enter the blood, let us inquire how the living particles gain an entrance into the vascular system in cases in which no wound is made, in which there is no solution of continuity in any part of the vascular walls. The fact that, of a number of persons equally exposed to the influence of contagium, some will contract the disease, while the majority will escape, may be accounted for by supposing either that in the latter case the particles do not really penetrate the vascular wall at all, or that, they are in some way destroyed as soon as they traverse the wall of the capillary and come into contact with the blood.

We must therefore enquire what circumstances would favour or assist the passage of the living particles of the contagious material through the vascular membrane into the blood. Thin-walled capillary vessels, as is well known, come very near to the free surface in many parts of the body, and if these capillaries are

distended with blood, their walls are rendered still thinner, and they come still nearer to the surface. The capillaries of parts of the mucous membrane of the nose, mouth, fauces, and conjunctiva, even in a state of perfect health, are covered with a very thin layer of protective epithelium, while those of the air-cells of the lung are practically bare. Through these, minute germs might readily pass. In many morbid states, the epithelial covering of the mucous membranes above enumerated, is very soft, and sometimes it is reduced to a thin layer of moist, pulpy mucous material in which any foreign particles would very readily become embedded. In such a material, contagious disease-germs would find a nidus suitable for their reception, and at the same time probably also soluble materials adapted for their nutrition. Having fallen into this, they would grow and multiply, and minute offsets from them might soon make their way to the external surface of the thin capillary walls.

When the capillaries are much stretched, as is always the case when they are fully distended with blood, the minute particles of living germinal matter or bioplasm of the blood, as well as diverticula from the white blood-corpuscles, readily make their way *out* of the capillaries through the walls with the blood serum, and grow and multiply in their new position. Even red blood-corpuscles, as is well known, often pass through the vascular walls under

these circumstances. In many kinds of inflammation this commonly happens.

Every one who has been in the habit of making minute injections of the vessels of tissues must be acquainted with the fact that little longitudinal rents or fissures in the walls of the capillaries, quite wide enough for a red blood-corpuscle to pass through edgeways, are easily made. It is therefore quite certain that particles can pass *from* the interior of the capillary vessels outwards with the greatest readiness, and without the occurrence of any actual rupture of the vascular wall. There can, therefore, be no difficulty in explaining how the passage of disease-germs in the opposite direction in a similar state of the capillary wall takes place. These little particles, like other forms of bioplasm, possess inherent powers of movement, and would easily insinuate themselves through any slight fissure which existed in the capillary wall. Such particles of living matter are even capable of passing considerable distances through the interstices of various tissues, like the living germs of some parasitic organisms, which, as is well known, often traverse a great extent of tissue before they arrive at the spot where they undergo development.

Again, it must be borne in mind that there are at very short intervals in the capillary walls masses of bioplasm (nuclei), which increase considerably in size when supplied very freely with nutriment. These

may divide and subdivide, and give rise to collections of little bioplasts "granular corpuscles," as seen in cases of inflammation of the pia mater, and also in cases of tubercular disease of the same membrane. The walls of the vessel are weak and liable to alterations in the situation of these nuclei, as the latter increase or diminish in size. Hence there is no difficulty in accounting for the passage of minute particles of the living contagious bioplasm in cases in which the capillary walls are diseased, and after they have been unduly stretched and have remained somewhat flaccid.

Now, the state of things referred to above—a soft moist state of the mucous surfaces, a dilated condition of the capillaries, combined with a weak, flaccid state of their walls, which always follows long-continued congestion, and which is intimately connected with a weak heart's action and feeble condition of the nervous system, are the very conditions which would facilitate the passage of living germs,—and is not this the state of things which exists in the organism about to be the victim of a contagious fever?

No doubt in these cases the composition of the blood is altered and its fluid constituents manifest a tendency to permeate the vascular walls more readily than in a perfectly healthy state. Such a state of blood would doubtless affect the action of the nervous centres presiding over the contraction of the arterial walls, and regulating the flow of blood through them,

thereby influencing the nutrition of the part. In this way a relaxed state of the arterial walls and a congested state of capillary vessels might be induced, or already existing, might be increased. It is this low and but too often ill-defined weak state of health, which often persists for some weeks before the attack of contagious disease occurs, that we should endeavour to detect, and at once treat. Nay, it is almost certain that every serious acute disease dangerous to life to which we are subject is preceded by a condition of system which in many particulars is a departure from health. If this can be altered, the liability to the supervention of the acute attack no longer exists. It is in the direction of anticipating the occurrence of actual serious well-marked disease that those most earnest in advancing medicine may reasonably hope to do useful work. And it seems certain that the more minutely we investigate, the more likely shall we be to learn how to discover and to appreciate that slight departure from the healthy state which precedes, and often by some considerable time, the development of many of the most serious and most fatal maladies. Were our knowledge greater we might perhaps in many instances succeed in warding off altogether the threatened invasion of disease.

Minute investigation in connexion with disease has been most unwisely discouraged, by purely scientific men on the one hand, and by those who confine themselves to their practical medical duties on the

other. By the first, because they think that medical practice affords occupation enough for one man ; by the last, on the ground that scientific work unfits a man for the practical duties. It has too often happened that the very few who have devoted themselves to real medical enquiry, have been unfairly treated, and by the very persons who ought to have afforded them support. The time has now arrived when the incentives to this course should be openly condemned, as resulting from narrow ancient prejudice, which has long survived its allotted term. Every intelligent person will do his utmost to further those branches of investigation which have already exerted so great an influence upon the discovery of the wonderful changes which occur in man's body in health and disease, and therefore upon the progress of medicine.

Of the Presence of the Germs in the Capillaries.— In every form of contagious disease, and during every period of its existence, the circulation through the capillaries is affected ; indeed, the essential phenomena of each special malady are due to changes in the quantity and quality of the contents of the capillary vessels. If recovery from the malady is rapid and complete, the capillary changes induced by the disease have been slight. If the disease terminates in death, the fatal result is occasioned by irreparable damage in and around the capillary vessels themselves, or it is occasioned by secondary changes in the tissues induced

thereby. The character of the eruption is determined mainly, and in some cases entirely, by the abnormal state of the capillary circulation, and even in those instances in which local alterations in vascular tension are unquestionably associated with nervous disturbance, this is often induced indirectly by a primary change in the capillary circulation, by which the afferent nerve fibres passing to the ganglia, are influenced. Disturbance consequently occurs in the ganglion, and the central variation excited in the intensity of the current is conducted along the efferent vaso-motor arterial nerves. In consequence, many little arteries become dilated, and the vascularity of the area of tissue supplied by them is increased.

In all cases of contagious disease which I have examined, the same sort of living germinal or bioplastic matter has been discovered in the capillary vessels of many of the affected tissues of the body. In some parts the vessels appear to be quite filled with a "granular," more or less transparent material, which, when fresh, may be stained by the carmine fluid, and exhibits the characters of bioplasm, the particles of which are, however, exceedingly minute.

I cannot explain fully and satisfactorily why the contagious material collects principally in the capillaries of the skin and mucous membranes, but I would remark that the masses of bioplasm in connexion with the surface capillaries are large, and project into their interior, Plate XVI, fig. 58, p. 136. Thus there are

many little eminences by which the further passage of the germs might be interfered with. The vessels themselves change much in volume many times during every twenty-four hours; the canal being sometimes far too narrow to permit a red blood corpuscle to pass, Plate XXVI, fig. 106, p. 188, while at others the tube is much dilated and filled with blood. Moreover, the capillaries often form loops, and sometimes little diverticula may be found here and there, in which particles might collect and accumulate to some extent, without the tube of the vessel being in any way obstructed.

The little particles of contagious matter having gained entrance into the blood and arrived at the superficial capillary, probably absorb nutrient material rapidly. It is possible that fibrin may become coagulated around these little bodies, just as if they were particles of pus, and the mass being too large to pass, may become impacted into some part of the capillary system. The large size of the white blood corpuscles in very many blood diseases is also a fact not generally known, although of great importance, which must not be lost sight of in considering this part of the question; but I cannot discuss it here. In those organs in which the circulation is slowest—as the spleen and liver—the conditions would be very favourable to the multiplication of such particles of living matter, and it is probable that in some cases the capillaries in these organs are principally affected in the

early period of the disease. From the collections thus formed, particles may be carried to other parts.

State of Blood favourable to the Multiplication of Disease Germs.—No investigation is likely to be more fruitful in valuable results than a very careful inquiry into the microscopical and chemical characters of the blood just before its invasion by contagious disease germs, and the alterations effected by them during the period of incubation. There is much reason to think that certain states of blood are favourable to the multiplication of the poison, while others, perhaps, render its destruction almost certain.

It is at least doubtful if the growth and multiplication of every kind of disease germ will occur in perfectly healthy blood, even if introduced and mixed with it. Numerous facts, which will occur to every practitioner, render it far more probable that—at least in the case of the great majority of contagious fevers—a certain state of blood must be induced before the contagious poison can grow and multiply, and produce new germs. No one has, however, yet succeeded in ascertaining exactly in what particulars such altered blood differs from the perfectly healthy circulating fluid, but it is not a state of blood associated with a large number of red blood corpuscles, or with a highly active condition of the oxidizing processes; nor is the condition under consideration brought about by living much in the open air, and by the plentiful supply of good wholesome food and water.

Although little has been discovered concerning the state of blood favourable to the growth and multiplication of disease germs, it has long been known that when fever, inflammation, and other blood diseases have become established, the composition of the blood is altered, and even in a slight feverish attack which constitutes an ordinary cold, the chemistry of the blood is temporarily deranged. The extractive matters soluble in boiling water are present in undue proportion, and it is probable that this increase arises from insufficient oxidation. Various matters which in perfect health are very highly oxidized, so as to be eliminated in the form of carbonic acid, urea, and other substances which are readily excreted, remain in the blood unoxidized, or are very slowly and with difficulty eliminated in a suboxidized state. Thus there remains in the blood an excess of soluble material, which permeates the tissues much more readily than ordinary healthy serum. This transudes through the walls of the capillaries, and is appropriated by the bioplasm of the blood, of the vessels, and of the tissues. The bioplasts or masses of germinal matter invariably increase in size under these circumstances. By this increased growth of germinal matter, which invariably takes place in all inflammations and fevers, the close analogy existing between these two classes of diseases is clearly indicated.

One important change in the composition of the blood when fever has become established, may be

demonstrated in a very simple manner. If the dried residue of the fever blood be extracted with boiling distilled water, it will be found that the proportion of matter dissolved out from the fever blood is much larger than that obtained from the healthy blood residue. Three specimens of blood taken from animals which died of the Cattle Plague, contained respectively, 2·91, 2·22, and 1·81 parts of soluble matter dissolved out by boiling water, or twice the quantity extracted from healthy ox blood. The exact amounts were as follows:—

	Healthy ox blood.		Blood from Cattle Plague.		
	1.	2.	1.	2.	3.
Solid matter obtained by evaporating 100 parts of blood	19·87	20·63	23·1	22·78	24·88
Substances soluble in boiling water	1·33	1·11	2·91	2·22	1·81

The solid matter of the two healthy specimens contained respectively 6·69 and 5·38 per cent. of matters soluble in boiling water, while the diseased specimens contained respectively 12·62, 9·72, and 7·22 per cent. So that not only is the percentage of the *solid matters* generally greatly increased in this form of fever, but the extractives and other substances soluble in boiling water are present in increased proportion. These substances probably constitute a pabulum, which is very readily appropriated by degraded forms of bioplasm.

Obstruction of the Capillary Circulation.—In all

diseases depending upon the presence of disease germs in the blood there is at length unmistakeable evidence of obstruction to the flow of blood through the capillary vessels of different parts of the body. If this obstruction is incomplete, and only affects a limited area of tissue here and there, the case terminates in recovery, but if, on the other hand, the capillaries of a considerable portion of the body are obstructed, and more especially if the heart's action in such a case should be weak, and the contractions of the left ventricle not sufficient to drive the blood forcibly towards those capillaries which may yet remain more or less pervious, the disease must be fatal, and probably during its early stage. It is therefore of the utmost importance in critical cases to excite the heart's action by giving remedies which are known to have this effect. *See* also page 140.

The contagious disease germs in some instances, as has been already suggested, are perhaps enveloped in a coagulum of fibrin, and thus are formed little masses which would be too large to traverse the capillary vessels. Mr. Lee showed that if pus was injected into the blood of a living animal, coagulation of the fibrin of the blood immediately occurred. In the case of some contagious disease germs, it is possible that the coagulation of fibrin around the contagious particles may only increase the size to that of a white blood-corpuscle, or little larger, but a body even of this size would, under some circumstances, fail to pass,

and being obstructed in its passage, further coagulation is necessarily occasioned, p. 175. Thus many capillaries would be stopped up, and small patches of highly turgid and obstructed vessels would result. Soon the germs enveloped by the coagulum increase and multiply, and thus after a while the cavity of the capillary vessel appears to be entirely occupied by them, and no blood whatever can pass through. This often leads to complete disorganization, which will be again referred to.

In some cases the obstruction depends rather upon the increase of the bioplasm of the capillary walls, which occurs in all inflammations and fevers, Plate XXVIII, p. 218, and is not due to the increase and accumulation of the contagious disease germs themselves.

But however the obstruction may be brought about, it is soon followed by most important changes, external to the vessels, in consequence of which the action of the tissues and organs involved becomes seriously deranged. It has been frequently proved that if, in certain states of the blood, particles of living matter allied to pus be introduced, phenomena which at length end in death, are occasioned. The blood cannot cease to circulate without the neighbouring tissues being deprived of nourishment, and if the obstruction remains complete for a few days, still more serious consequences ensue. Not only are the vessels themselves destroyed, but the adjacent textures are involved in the common ruin. Separation of the

textures by the formation of *sloughs* not unfrequently occurs; but where neighbouring vessels and lymphatics remain healthy, the removal of disintegrated tissue is sometimes effected by absorption, in which case portions of the tissue or organ afterwards appear as if they had wasted.

With regard to the particular capillaries obstructed, it has been already remarked, that those of the cutaneous and mucous surfaces are most seriously involved in many contagious fevers, but these are by no means the only vessels affected. In some diseases the capillaries of the liver and spleen are the seat of change, while in certain forms, those of the lungs, kidneys, and other glands, and even those of the muscular and nervous tissues suffer to such an extent, that part of the organ may undergo most serious pathological change, or be completely destroyed.

Destruction of Vessels and Tissues.—Wasting of tissue, usually circumscribed, which not unfrequently follows a bad attack of contagious fever, is a direct consequence of the vascular changes which have been referred to. In such cases the organism is often seriously and permanently damaged, and the normal state can never be regained. There is not a tissue or organ in the body which is certain to escape the terrible consequences of a severe attack, but happily cases in which many organs in one individual are seriously damaged, are rare, for, as a general rule, when the disease is sufficiently severe to produce

such a result, it ends fatally. Still, we meet with many instances, where serious local damage has happened, as, for example, where permanent local paralysis follows continued fever, diphtheria, and scarlatina, or destruction of the delicate textures which form the nervous portion of the organs of sight and hearing, especially as a consequence of the last condition. Nor is prolonged or permanent derangement of the health and imperfect nutrition an uncommon consequence of the changes effected in and around the capillaries in many cases of different kinds of contagious fever, which are due to the entrance of disease germs into the blood. A very good notion of the sort of change which occurs may be formed if the great alterations which are induced in the villi as a consequence of cholera, be carefully studied.

If such changes have affected an extensive tract of small intestine, it will be seen that the proper functions of this important surface can never again be properly discharged. Although, no doubt, in the healthy state there is a much greater extent of absorbing surface than is really required, it must be obvious that if this be very much reduced, as is the case after a severe attack of cholera, the effective absorbing area will be too limited to take up the quantity of nutriment required to maintain the body in a state of health and vigour. Nor, after a careful consideration of the serious changes induced in the vessels and other tissues of the villi in cholera, shall we be surprised that serious

attacks generally prove fatal. The obstructed vessels of the villi are represented in Plate XXI, figs. 79 to 86, under a low magnifying power. The villi themselves are much smaller than in health, and some are completely disorganised (Fig. 84). Lieberkuhn's follicles are also seen to be shrunken, short, and wasted, and some have completely degenerated (Fig. 86). In Fig. 85 the narrow openings of wasted follicles are represented. These are very much smaller, and are separated from one another by a much greater distance than in health. Many of the vessels represented in these drawings are so changed and disorganised, that it is impossible they could ever again have transmitted blood. Had the patient recovered, many of the villi figured would have disappeared.

The capillaries in many of the villi have wasted in a manner and to an extent which is very remarkable. A specimen has been represented in Pl. XXI, fig. 82, which shows the alterations very distinctly, although they have not yet proceeded to an extreme degree. In Pls. XXII, XXIII, a more advanced stage of disorganisation, is represented. At the summit of the villus in Figs. 87, 88, p. 186, many of the capillaries have become reduced to mere lines, and the texture a short distance from the surface has wasted; indeed much of it had completely disappeared. In the intervals between the lines which mark the positions occupied by the capillaries is a little indeterminate tissue, in which several oil-globules are seen.

In Figs. 82, 89, the vessels have not wasted to the same degree, but their outline is irregular, and they are filled with an almost colourless material. A greater quantity of the tissue of the villus remains in the meshes of the capillaries in Fig. 87 than in Fig. 90. It is clear that the blood could not have circulated at all in these vessels for some time before death. Any blood that remained stagnant in the larger ones had become altered. Its colouring matter had disappeared, proving that many days had elapsed since the obstruction had first occurred. Those constituents of the tissues which were incapable of absorption have undergone great change. Among the resulting products is fatty matter in considerable quantity (Fig. 88).

In some cases there was demonstrative proof that some time before death blood had actually passed through the capillary walls into the surrounding textures. Crystals of hæmatoidin, as well as oil-globules, were found in considerable number in this situation, as represented in Fig. 88. This circumstance proves that the villus had not been in a healthy condition, even for some time before the attack.

Villi exhibiting the structural alterations described cannot be organs of absorption. Neither could secretion have taken place from the follicles. The passage of fluid out of the vessels must have ceased long before they became reduced to the state figured. They must now be regarded as mere processes of de-

CAPILLARIES OF VILLI. CHOLERA.

Fig. 79.

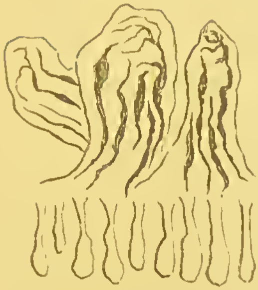


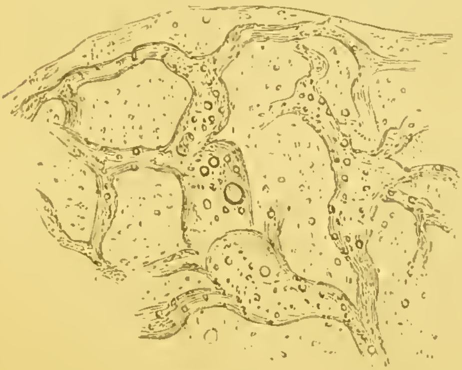
Fig. 80.

a

Fig. 81.

Vertical sections through mucous membrane of small intestines in cases of cholera showing enormously distended vessels of villi and wasted Lieberkuhn's follicles *a* small arteries in submucous areolar tissue filled with clots. × 40. p. 183

Fig. 82.



Vessel with bulgings consequent upon obstruction. From the summit of a villus. (Cholera, case 4) × 215. Oil globules are seen in great number in the vessel itself and in the tissue external to it. pp 183, 197.

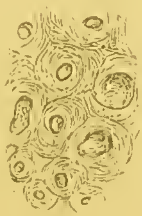
Fig. 83.

Cell-like mass represented at *b*, Fig 89. The dark bodies in the lower part may be bacteria × 1800.

Fig. 84.

Villi of small intestine, cholera, showing distended vessels of villi with complete disorganization of capillaries and tissues at the summit × 40. p. 183

Fig. 85.



Orifices of Lieberkuhn's follicles of small intestine—much wasted. × 40.

Fig. 86.

a

Irregular and much altered villi Cholera *a*. Lieberkuhn's follicles much altered wasted and degenerated. × 40. p. 183

$\frac{1}{100}$ of an inch ——— × 40.

$\frac{1}{1000}$ " " ——— × 215.

generated tissue, useless to the economy, and destined to be removed, and their place occupied by new organs, if life had been preserved.

The changes affecting the capillary vessels as they appear under high powers, will be understood by reference to Figs. 82, 87, to 94. Fig. 91 shows the capillaries of the villus in an almost healthy condition.

It is quite certain that the morbid changes delineated in these drawings must have been progressing some time previous to the attack which destroyed life. It may be confidently affirmed that such changes as those described could not have taken place in a few days. There is sometimes evidence of alterations which must have been going on, even for weeks before death. The kind of degeneration which has been observed obviously requires some time for its completion, although I have not the data to enable me to fix the precise period. The time requisite for the changes which occur in blood-clots can be ascertained accurately in some cases, and we have no reason for inferring that the red blood-corpuscles could be much more quickly disintegrated in the tissue of the villi, or hæmatoidin crystals formed in a shorter time, than in other situations.

In many of the specimens of small intestine from cholera cases I have found villi in every stage of wasting—the villus in which the change has only just commenced, and villi of which all that remained were little stunted elevations, projecting slightly from the surface of the mucous membrane. Had the patient

recovered, I am of opinion that new villi would have been formed, and to some extent have replaced those which had been removed. As I have already remarked, in a given area of intestine in cholera cases there are fewer villi and fewer Lieberkuhn's follicles than in health, and I believe that many victims of this disease had been suffering from degeneration of their villi for a long while before the occurrence of the attack of cholera, which proved fatal. The constant introduction of bad food and water, and in many instances terrible deficiency of food of all kinds, will sufficiently account for the marked changes which have been described. I think the evidence advanced in favour of the view that *healthy* persons die of cholera is defective and inconclusive, and believe, if this scourge is ever to be prevented, it will be by constant and unremitting attention to the food and general habits of life of the poor, not merely while we are appalled by the actual presence of the scourge, but at all times. There seems reason for thinking that it is possible by good management to prevent people from being attacked by cholera. Have we not reason to conclude that much may be done to prevent people from *becoming subjects for the cholera poison?* We know, alas! that we can do little, sadly little, to cure those attacked—though, perhaps, very much to improve the health of those liable to attack. We might thus mitigate to some extent the severity of the disease, and improve the patients' chances of recovery. I should waver in these views

SUMMIT OF VILLI—CHOLERA.

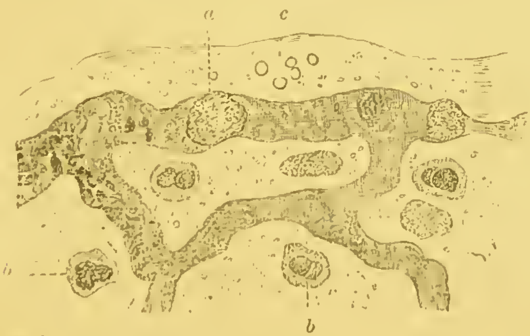
Fig. 87.

Shrunken and altered vessels from the summit of a villus. Jejunum. (Cholera, case 5.) Thickening of apparent 'basement membrane.' × 700. p. 181.

Fig. 88.

Part of the summit of a villus. (Cholera, case 6.) *a*, crystals of hæmatoidin. The vessel was pervious up to the point marked *b*, beyond which mere lines were discernible. The normal tissue of the villus had completely disappeared, and numerous oil globules were disseminated through what remained. × 700. pp. 184, 197.

Fig. 89.



Altered capillaries, from the summit of a villus. (Cholera, case 1.) *a* represents a large mass of germinal matter in the vessel, probably an altered white blood corpuscle. *b*, some cells apparently in the tissue of the villus, perhaps in the lacteal; one of these is represented more highly magnified in Fig. 83, Plate xxi. *c*, oil globules. × 700. p. 181.

$\frac{1}{1000}$th of an inch ———————— × 700.

[To face page 181.

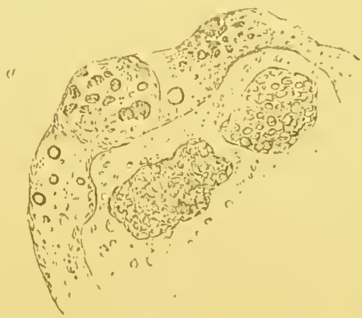
Fig. 90.

Summit of a villus. Jejunum. (Case 5.) Showing shrunken and wasted vessels and thickening of apparent 'basement membrane' of villus. × 700. p. 185.

Fig. 91.

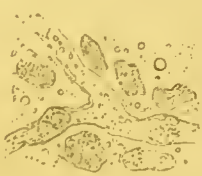
Summit of a villus from the jejunum. (Case 4.) Nearly healthy, *a*, lacteal. × 700.

Fig. 92.



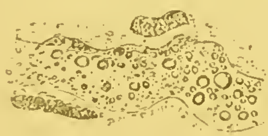
Capillary vessels, from the summit of a villus. Containing a large mass with dark pigment granules and oil globules in its interior. In various places very minute bioplasts are seen. × 1,800. p. 185.

Fig. 93.



Capillaries and bodies external to the vessel. (Case 3.) × 700. p. 185.

Fig. 94.



Vessels from the summit of a villus. (Case 3.) Containing numerous oil globules. × 700. p. 185.

[To follow plate XXII.

if I should obtain but a single specimen of small intestine in which I could not demonstrate diseased and altered villi. So far I have found them, without exception, in every case I have examined, and hence I have been led to form the above opinion, which becomes stronger as I work on.*

Multiplication of the Disease Germs in the Infected Organism.—From the observations already advanced concerning the size of the smallest living particles capable of growing and multiplying, it will be inferred that the actual quantity of contagious bioplasm sufficient to produce a contagious disease is wonderfully small, and that within the organism this minute particle multiplies a million-fold.

The contagious disease germs, like particles of germinal matter in inflammation, multiply enormously, not only in the blood vessels (Plates XXIV and XXV), but after having passed through the capillary walls, and gained the interstices of the tissues, Plate XXVI, they grow there, and not only

* I regret to have to notice here that a distinguished pathologist has stated that he has failed to confirm my observations upon the villi. It would have been but fair had he taken the trouble to look at my specimens before condemning my statements. It is probable he did not employ a method of examination which would afford a chance of success—certain that he did not proceed as recommended. Such hasty and confident assertions are calculated to excite distrust in the minds of many, but this cannot be helped. The observer simply records the facts, and if others, who have not taken the trouble to ascertain whether they are true or not, think proper to contradict him positively, he cannot prevent the practice. Speaking solely from what he has actually observed, and delineating carefully what he has seen, he may safely leave to those who contradict his observations the satisfaction of registering their contradiction.

appropriate the nutrient matter which is required by the bioplasm of the tissue, but they may even grow at the expense of the latter, Plates XXIV and XXV.

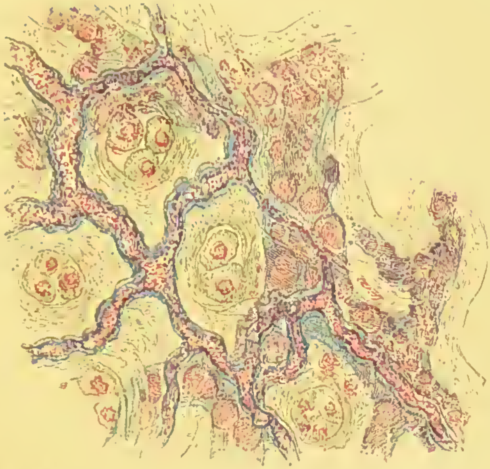
The bioplasm of the tissue may be killed and the tissue completely destroyed. The latter very soon ceases to discharge its function, and gradually it deteriorates in structure, and at length undergoes disintegration. Bacteria may be developed in it, and its decomposition may even occur in consequence of the rapid growth and multiplication of the germs of some contagious fever. In Plate XXVI will be found drawings which illustrate some of the remarks just made, and in Plate XXV, fig. 99, is a drawing which shows very well the vast growth of bioplasm amongst the vesicles of adipose tissue in ordinary inflammation.

We have now to inquire more precisely into the circumstances under which the wonderful increase of the poison is brought about. There are two views essentially different from one another, which may be supported by different arguments.

1. It might be maintained that the contagious material actually passing into certain portions of the living germinal matter of the organism excited in these new actions, and caused them to divide and sub-divide very actively, and communicated to them the same properties which the original particle possessed, somewhat in the manner in which the wonderful powers existing in connexion with the germinal matter of the spermatozoon are communicated to that of the ovum and affect to some extent every one

DISEASE GERMS IN VESSELS—CATTLE PLAGUE.

Fig. 95.

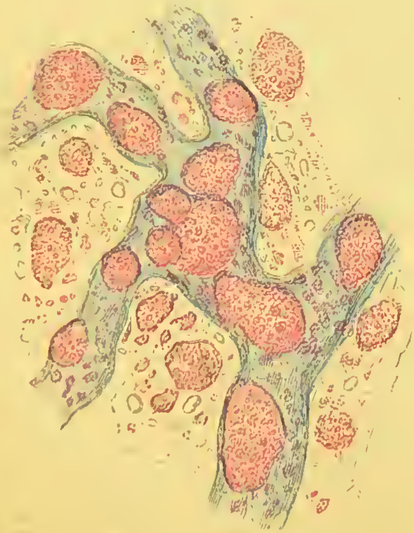


Surface of mucous membrane of fourth stomach Cattle plague, corresponding to a thin depressed circular spot like an ulcer : *a*, superficial capillary vessels varying very much in diameter, filled with (disease germs) minute particles of germinal matter or bioplasm. The orifices of several gastric glands are seen in the spaces bounded by the vessels, and the deeper vessels on a lower plane are also delineated × 350. p. 187.

Fig. 96.

Portion of one of the larger vessels on the surface of the mucous membrane represented in Fig. 95, containing masses of bioplasm. × 1,800.

Fig. 97.



Capillary vessels from the surface of a villus containing large masses of bioplasm and minute bioplasts (disease germs). × 700. p. 188.

$\frac{1}{1000}$ of an inch

Fig. 98.

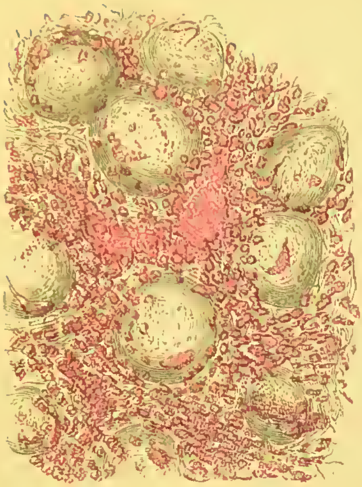
Capillary loop from Malpighian body of kidney Cattle plague. Containing numerous white blood corpuscles and many minute bioplasts (disease germs). × 700. p. 188.

× 700.

[To face page 188.

BIOPLASM—CATTLE PLAGUE.

Fig. 99.

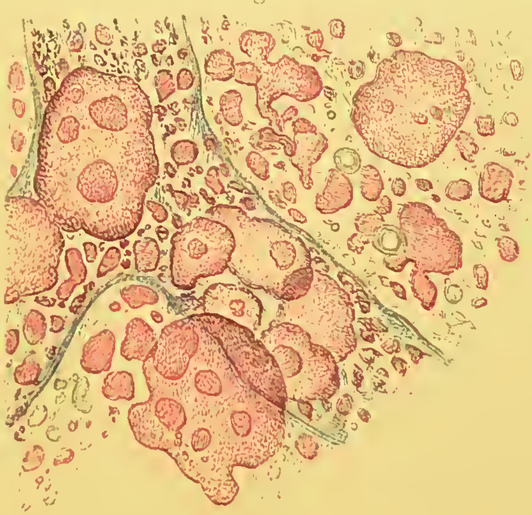


Fat vesicles and areolar tissue from external coat of vein of horse, three days after it was opened by operation. Multitudes of bodies like white blood corpuscles (bioplasts), and probably direct descendants from them, are seen in the intervals between the fat cells which in some instances were dyed with the altered and dissolved colouring matter of the blood, the greater part of which had however been removed. The bioplasm represented in this figure is harmless, but could not be distinguished from the contagious particles in other figures in this plate. × 215 p. 188.

Fig. 100.

One of the loops of vessels in a papilla of the mamma, cattle plague. Just under the eruption, fig. 103. The epithelium has been removed. The morbid bioplasm *a*. (disease germs) is seen just at the summit. The bioplasm of the epithelial cells. *b*. is much increased. × 700

Fig. 101.



Portion of a capillary from the surface of a villus. Small intestine from a very bad case of cattle plague. The vessels were covered with large and small masses of bioplasm, and contained masses of the same character in their interior. Complete disorganization had occurred. × 2,800.

$\frac{1}{1000}$ of an inch —— × 215.

" " " ———— × 700.

$\frac{1}{10000}$ " " ——— × 2800.

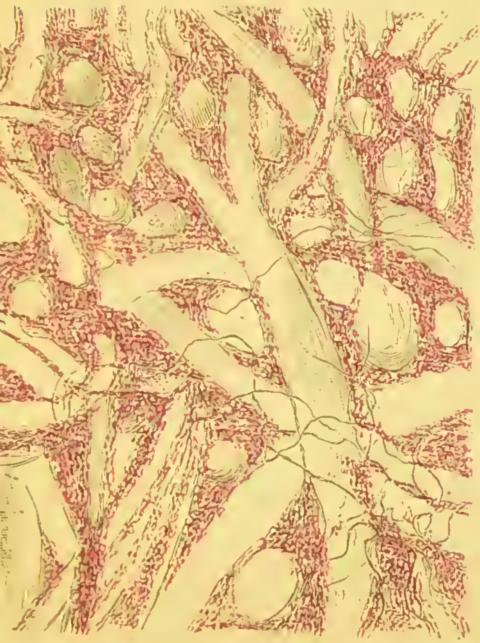
To follow Plate XXIV.

DISEASE GERMS.—CATTLE PLAGUE.

Fig. 102.

Vertical section through the centre of a well-marked papule (pustule ?) from the udder of cow, with cattle plague, sent by Mr Ceely January 11th, 1866. The eruption and roseolous rash were well marked. There were also numerous scales. *a* is the central softened portion of the papule. Natural size.

Fig. 103.



Fibrous tissue of the corium or true skin from the softened part of the papule, *a*, Fig. 102. The intervals between the fibres occupied with bioplasm (disease germs) growing and multiplying rapidly. × 215. p. 188.

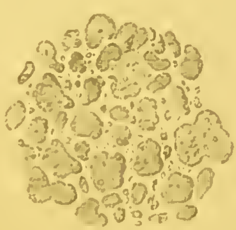
Fig. 104.

A portion of Fig. 103, magnified 700. The masses of contagious bioplasm can be seen dividing and subdividing into new portions which are growing rapidly and invading the bundles of white fibrous tissue. p. 188.

Fig. 106.

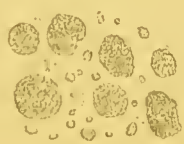
Capillary. Retina of calf (cattle plague) showing enlarged nuclei, *a*, of the walls projecting into the interior of the vessel. *b*, enlarged white blood corpuscle. *c*, *c*, *c*, red blood corpuscles. × 700.

Fig. 105.



Minute particles of contagious bioplasm from the fibrous tissue of the skin, beneath the eruption. (Fig. 101.) × 1800.

Fig. 107.



Masses of bioplasm from the external surface of a villus, cattle plague. × 700.

$\frac{1}{1000}$ of an inch ______ × 215.

" " " ______________ × 700.

of the multitudes of living particles resulting from its division.

2. The contagious particle or particles having gained access to the fluids of the uninfected organism may absorb nutrient matter, grow and multiply, and give rise to a progeny very closely resembling the originals.

In the first case the actual living matter of a healthy organism is supposed to take upon itself a new and peculiar action in consequence of the influence of another kind of germinal matter upon it. In the second the contagious material simply grows and multiplies at the expense of the pabulum.

It is open to discussion which of these two views is supported by the greatest number of and most pregnant facts. I incline strongly to accept the latter as the more probable of the two.

It may, however, be fairly asked, when a pus corpuscle from the surface of the conjunctiva of a person suffering from purulent ophthalmia, or when a particle of gonorrhœal pus comes into contact with an uninfected conjunctiva and grows and multiplies, establishing a similar morbid condition to that in operation upon the surface where it grew,—whether the multitudes of resulting pus corpuscles are the direct descendants of the original specific pus corpuscle, or are derived from the bioplasm of the blood or of the cells of the conjunctiva, which is modified in consequence of its action upon it.

It seems to me probable that the corpuscles capable

of exciting a new action upon an unaffected surface are the direct descendants of the original corpuscles which excited that action. Not only so, but I believe they take the nutrient material which was destined for the nutrition of the normal bioplasm, and live at its expense. Just as in the case of cancer, the adventitious rapidly growing germinal matter takes the nutriment destined for the normal tissue, and even feeds upon the latter in consequence of its powers of growth being much more active.

At the same time in the case of the specific pus-corpuscles growing upon a mucous surface there is no doubt that the germinal matter of the normal cells increases and multiplies too. Indeed, in some instances I have proved that this is the case, so that there are two distinct processes going on—1, the multiplication of the specific bioplasm, and, 2, the multiplication of the germinal matter of the normal cells modified by the altered circumstances to which it is exposed. And it therefore follows that not every one of the pus-like bodies formed is capable of exciting the specific inflammation, but the morbid bioplasts outstrip to so great an extent, in the rate of their multiplication, the masses of normal germinal matter, that the number of descendants of the latter would be comparatively insignificant, and would soon be completely overwhelmed by the former.

Upon the whole, then, I venture to conclude that the millions of contagious particles produced in the

organism in an eminently contagious disease, are all the direct descendants of the very few, or perhaps even single particle first introduced ; just as the millions of bacteria and fungi developed in certain decomposing organic matters in the course of a few hours may have been produced from one or at most a very few particles. And that although in the secretions upon the mucous surfaces, and in internal parts, there may be many masses of germinal matter resulting from the increased access of pabulum already many times referred to, these latter do not form the active elements of the contagious material or contagium.

Concerning the Possibility of Disease Germs passing into the substance of Normal Living Bioplasm.—It is true that in the substance of many masses of germinal matter found in the secretions and discharges of animals dying from cattle plague, and of many other diseases, some minute particles which would ordinarily be termed "granules," which refract the light very highly, and probably have been often mistaken for minute oil globules, may be invariably observed in great number. The nature of these particles is not known. They are met with in almost all kinds of living matter with which I am acquainted, and different forms are observed. In Pl. XIX, fig. 71, some are seen in masses of germinal matter from the milk. It seems to me probable that some of these particles have originated in the germinal matter itself, while others have passed into it from without.

Now it is certain that such particles are very numerous, and are commonly found in masses of bioplasm so situated as to render their entrance from without not only possible, but probable. The fact of the amœba opening itself as it were, and then enclosing upon foreign particles, and embedding them in its very substance, is well known. Nor is this a phenomenon peculiar to the amœba, but it is possessed by other kinds of germinal matter. And now that the supposed importance and even the actual existence in many cases of the cell-wall has been disproved, and the active spontaneous movement which used to be called amœbiform, because it was supposed to be peculiar to the amœba, has been proved to be common to living matter in general, it is probable that this and other *vital* properties, equally characteristic of all kinds of matter in a living state, will at last be admitted.

It must then be regarded as at least possible that particles of contagious living matter less than the $\frac{1}{100000}$ of an inch in diameter might pass into the substance of a white blood, lymph, or chyle corpuscle, and thus embedded, the particle might be carried to all parts of the system. The matter itself might increase and multiply in the corpuscle, destroying it and living at its expense until the new collection attained a size larger than that of the corpuscle; or the foreign living particles in the white blood corpuscle might interfere with its division and sub-

division, and the germinal matter of the corpuscle itself, attain a size larger than ordinary; or the presence of the bodies supposed might cause the death of some of the particles of germinal matter and the formation of oil globules and other substances which might go on accumulating until the white corpuscle became too large to traverse the smaller capillaries. The phenomena above referred to would not only seriously interfere with the growth and nutrition of the white blood corpuscles, but would prevent the material undergoing conversion into red blood corpuscles; and in consequence of the diminution in number of the red blood corpuscles, and the reduction of the total quantity of blood in the system, various secondary phenomena would ensue.

But in whatever way the minute particles of germinal matter supposed to be included in the white blood corpuscle might cause their enlargement or interfere with their function, impediment to the free circulation of the blood in the capillaries must be induced. The minute particles now stationary would rapidly increase and multiply, and some might make their way through the vascular walls towards the surface, or into the surrounding textures.

The minute particles embedded in the germinal matter sometimes so closely resemble minute vegetable germs that in some cases it is difficult to believe they are not of this nature, and have gained access from without. In other cases these particles are of

the nature of nuclei, and have originated in the germinal matter itself, while I am quite certain that some of the minute highly refracting particles embedded in the white blood-corpuscles, pus-corpuscles, and some other masses of germinal matter, result from changes occurring in the germinal matter itself, and are closely allied to fibrin.*

Of the Escape of the Contagious Bioplasts from the Diseased Organism.

There are three ways in which such minute particles of living matter as contagious disease-germs have been proved to be, might escape from the system in which they have been developed. These may be stated as follows:—

1. The living disease-germs might make their own way through small chinks or fissures in the capillary wall when it is overstretched.

2. They might be removed from the blood suspended in the fluid which is made to exude through the vascular wall.

3. It is supposed by many that disease-germs may be, as it were, attracted through the walls from the blood by the action of epithelial and secreting cells situated outside the vessels.

The view which has long been entertained and is

* "On the Germinal Matter of the Blood; with remarks on the Formation of Fibrin." Trans. Mic. Soc., Dec., 1863.

most in favour at the present time, is the last. The opinion seems generally held, that disease-germs, like urea, uric acid, and other poisonous matters present in the blood may be selected and separated from the normal constituents of the circulating fluid by the agency of cells situated external to the vessels, and thus "eliminated" from the organism. But there is no analogy whatever between *non-living* urea and uric acid, and *living* disease-germs, while it is an error to suppose that if fluid is discharged from the blood the process is invariably due to the influence of epithelial or other cells. The result is often, I believe almost invariably, dependent upon other circumstances altogether. So far from the epithelium taking an active part in the process, this structure is often damaged and sometimes destroyed and stripped off by the free escape of fluid from the blood, or before any discharge has commenced to take place.

The escape of the fluid is usually associated with a highly distended state of the capillary vessels. There have been stretching and consequent thinning of the capillary walls in these cases. Even after death fluid will transude through the capillary vessels which have been involved, with undue readiness. This I have frequently noticed in injecting the vessels of persons who have died of cholera. Although the fact has not been observed in every case, it has occurred too often to be regarded as a mere accident, and in many instances the phenomenon was so

striking that it could not fail to excite immediate and careful attention.

In order to make a good artificial injection of healthy capillary vessels, it is necessary, as is well known, to employ some force in pressing down the piston of the syringe, and the injection is seen to spread very slowly from the points where it first appears. It is only after several minutes that the injection becomes complete. In many cases of cholera, however, the injection seemed to run into the most minute capillaries almost instantly, and under very slight pressure indeed. The capillaries seemed to be filled at once, and extravasation occurred, without any force having been exerted, within half a minute after the injection had been commenced. While injecting the vessels, one was forcibly reminded of what takes place when fine injection is introduced by the aid of very slight pressure into one of the large vessels of a mollusk—the force required to inject the smallest vascular ramifications, which in this class are very large, being so slight that the injection will pass freely into the smaller vessels, although it runs out very fast through the opening made in the larger one, in which the pipe is placed without being tied.

I think there is little doubt that this increased facility of injection depends upon the extreme stretching to which the coats of the capillaries have been subjected during the course of the disease. The

elasticity of the vascular walls had been much impaired during the progress of the disease, and I think it likely that in many instances the stretching had been carried to such an extent as to reduce the capillaries to a state of extreme tenuity, and to produce slight fissures in every part of the capillary wall through which the injecting fluid readily escaped after death. In some of these same cases we know blood-corpuscles had passed out during life.

Now there can be no question as to the extreme distension suffered by some of the capillary vessels in cholera. In Fig. 82, plate XXI, p. 184, some capillaries are shown stretched to three or four times their ordinary diameter, and yet there is no evidence of actual rupture having occurred. It appears probable, however, that in many instances the distension is succeeded by the giving way of the capillary walls, when hæmorrhage takes place into the surrounding tissues. This appears to have occurred in the specimen from which Fig. 88, plate XXII, p. 186, is taken. In various parts well-defined crystals of hæmatoidin were observed, as well as numerous oil-globules which have resulted from changes having taken place in matters which have extravasated from the blood. The tube of the capillary vessel may be traced up to a point indicated by the letter *b*, but beyond this the only indications which remain of its further course are a few irregular lines. This vessel was pervious, and was injected with fine Prussian blue fluid as far as the

point marked. Below this point its walls were very permeable, and permitted the fine Prussian blue injection* to pass through them readily.

Capillary hæmorrhage, as is well known, although frequent in cholera, is by no means constant. It is probable that in many capillaries extreme distension is followed by cessation of the circulation and stagnation of the blood, which then undergoes change, much of it being re-absorbed. The vessel after shrinking very much gradually wastes, as has been already described.

It would seem, therefore, that in this case a free escape of fluid occurs, and any disease particles present would be removed in the blood. The circumstances, therefore, which gave rise to the stagnation of the blood and the distension of the capillary vessels must be regarded as the cause of the escape from the blood of fluid holding in suspension the disease-germs. Neither the epithelium which had probably been removed long before, nor other structure external to the vessels were actively concerned in the discharge of fluid or in the removal of the disease-germs.

As, however, it has been maintained that "elimination" performs a very active part in the removal of matters from the blood, and that living disease-germs

* For the composition of the Prussian blue injecting fluid, see "The Microscope in its Application to Practical Medicine," 3rd edition; or "How to Work with the Microscope," 4th edition.

are "eliminated" from the infected organism, it is desirable to consider the nature of the process called "elimination" as it occurs in health and disease.

On Elimination.—The idea that poisons of all kinds are eliminated by a natural process, and that the operation is effected through the agency of the cells of certain tissues and organs, has of late years taken so firm a hold upon the mind as to be regarded by many writers as a well-established pathological fact. If, however, the view which is entertained be carefully analysed, and the supposed phenomena examined by the light of modern investigation, little indeed will, I think, be found to justify the doctrine that cells take an active part in removing poisons from the blood, or that it is part of their duty to "eliminate" such deleterious little particles as disease-germs which have gained an entrance. Indeed if this were part of the work of these cells, we could not help acknowledging that they performed their duties most imperfectly, and failed more often than they succeeded in separating from the blood the poison which had entered. And it would certainly appear very strange that the cells did not "eliminate" the small amount of poison soon after it had entered, instead of remaining perfectly passive until it had accumulated to an enormous extent, jeopardized the life of the patient and seriously impaired the action of the very apparatus that was to take an active part in expelling it from the body. So far from the cells

which are supposed to conduct this beneficial operation being active, it is probable they are perfectly passive, and have nothing to do with removing the disease-germs. So far from having any affinity for the particles they are supposed to eliminate, the secreting cells are damaged or destroyed by the latter, which may take up pabulum which the normal cells should have absorbed ; or in their escape from the body the disease-germs may forcibly detach and destroy the healthy tissue supposed to be instrumental in elimination.

Let me now try to determine what is generally understood by this act of "elimination," which is supposed to play so important a part in physiology and pathology. By this process it is held that certain substances existing in the blood are removed from that fluid. The agents by which this removal is effected are the gland cells, and it is supposed that these possess an *attraction* for the particular substances which it is their duty to eliminate, by virtue of which they are enabled to select and draw towards themselves these special matters. It seems further to be generally concluded that the gland cells, after having taken up the particular substances in question, at least in some instances, produce in them important alterations and convert them into new compounds. When the change is complete and the gland cells have attained their mature state, it is supposed that they are cast off from the surface loaded with the materials they have

modified and are about to eliminate. In short, the gland cell is supposed to take up certain matters as cells in general take up nutrient materials—to grow, to pass through certain phases of existence, and to die, its contents being set free at the time of its destruction. The place of this cell is then occupied by a new one which grows up. If this view is correct, it follows that numerous cells in every gland must grow, pass through their several stages of existence, and die in the course of a few hours at most; and necessarily the changes occurring in the cell must take place very quickly indeed.

Now what are the facts which lead us to conclude that in the ordinary process of secretion the cells are thus destroyed bodily? It is indeed quite true that cells occupying different positions in a gland follicle exhibit different characters, the most mature cells apparently containing the perfectly elaborated secretion. But does this fact alone prove that these cells are removed and renewed as fast as the secretion is formed? Can the fact be only explained upon such a view? There is no doubt that the epithelial cells are gradually cast off bodily from the surface of the cuticle and mucous membranes and replaced by new ones, which grow up from below; and this is an argument in favour of the occurrence of a similar process in glandular organs, but the analogy has surely been much overstrained. The rate of desquamation of cuticular epithelium for example is not very rapid,

but it must be slow indeed compared with the desquamation of liver and kidney cells that must take place if the bile and urine discharged are set free by the rupture and destruction of epithelial particles. But what shall we say concerning the gastric juice, in which case many pounds of secretion are poured out in the course of twenty-four hours from glands which, with their vessels and other structures included, weigh but a few ounces? Does the formation of every drop of gastric juice necessitate the destruction of an equal bulk of gland cells? Is it not much more probable that the secretion filters away fully formed from the gland cell as fast as it is produced, while the latter remains apparently unchanged? In the case of the cuticular cell, it is necessary to inquire if the hard epithelial material is the *only* thing eliminated by its agency. Was it not very moist at an early period of its life, and is it not probable that much liquid holding various soluble substances in solution filtered through it and was carried off for a long time before the cell itself was cast away?

If the formation of a liquid secretion, like the bile, urine, or gastric juice, involved the growth and destruction of epithelial cells, the quantity of the secretion formed in these cases is so very great that the growth of the cells would take place very quickly. I think that we ought to be able to see, under our microscopes, the actual process of growth taking place—if not in man, at least in some of the lower

animals—just as we can see the movements of the blood, lymph, and chyle corpuscles, and the wonderful alterations in form and size of the mucus and pus corpuscles and portions detached from them.

Many circumstances, however, render it far more probable that the act of secretion, and "elimination" of excrementitious substances from the blood, *does not involve the destruction of the cell.* That every cell grows old and dies is certain; but the process is much slower than it would be if the functional activity of the cell involved its death as a whole. The facts arrived at from a careful study of the cells at different stages of development lead me to conclude that every cell, instead of secreting only its own weight of matter, elaborates and eliminates a hundred, or a thousand, or ten thousand times its weight of material in its lifetime. The doctrine generally entertained upon this point involves an extravagance of cell destruction which neither the results of anatomical observation nor the conclusions arrived at from physiological experiments permit us to entertain.

In secretion and elimination it is probable that the germinal matter of the cell absorbs the materials from the blood, and converts these into matter like itself, while at the same time a portion of the germinal matter already existing dies, and undergoes conversion into those substances which constitute the secretion, according to the explanations given in my papers on

nutrition, &c., in the "Medical Times and Gazette," March, 1865. The cell may thus take up a quantity of material, convert it into new constituents, and discharge these into its duct, without itself undergoing any appreciable alteration either in form or weight.

A large quantity of urea or uric acid may, I think, be "eliminated" from the blood without the destruction of a vast number of renal cells. Lactic acid, and lactates, and ammoniacal salts may be "eliminated" by the agency of the cells of the sweat glands without these cells being destroyed and replaced by new ones. Other lifeless soluble substances may be separated from the blood and eliminated in the same way, but it is very improbable that the cells of secreting organs should also attract towards them particles of *living matter* and afterwards "eliminate" these in an unaltered and living state.

I would remark here that when the eliminative act does undoubtedly involve the destruction of the organ of elimination, we have an arrangement very different from that observed in the permanent or true glands possessing ducts. The secreting organ in that case is a closed follicle, like the "solitary glands" and the glands constituting Peyer's patches in the alimentary canal. The little "cells" or masses of germinal matter, of which the gland is composed, grow and multiply, and retain in their substance at least a great part of the nutrient pabulum they take up. The mass

composing the closed gland therefore increases in size, and approaches the surface of the mucous membrane; an opening is formed, and the contents escape. The walls of the old gland shrivel up, the wound in the mucous membrane heals, and probably a very slight cicatrix, with a little condensed areolar tissue beneath, is all that marks the seat of the gland. But even in this case we cannot affirm that the "cells" which have elaborated the secretion die and discharge their contents. They escape from the cavity in which they grew, but has anyone shown that they die and undergo rupture? We have much to learn concerning the destination of these "cells" in the closed glands which escape by rupture of the capsule of the gland. We know that "cells" of the same kind formed in the spleen have a very different office and destination. They seem to be but commencing their career when they become free, and I could bring forward several facts which justify me in expressing a strong opinion that the life of the cells does not cease when the temporary follicle in which they grew becomes ruptured and permits their discharge. On the contrary, it appears to me that at this very time they commence the really important part of their life-work, and they may now be only beginning to perform their active duty for the first time; so that neither in the case of the secreting glands with permanent ducts, nor in that of the temporary closed glands, can I admit that the doctrine which maintains that the

formation of a secretion involves the detachment, death, and destruction of the cell which formed it, rests upon sound evidence.

We have now to inquire how far the term "elimination" is appropriate, when speaking of the removal of living disease germs from the blood. It is true we are told that the living self-propagating germs of scarlatina are "eliminated" by the skin and kidneys, but no evidence is adduced in favour of such a view. Like many doctrines, it is accepted as if it had been proved, although arguments have not been adduced in its favour. We may, however, now form a more exact notion of the kind of matter the poison in question really is, and of the way it escapes through textures from the blood and from the body, and we are, perhaps, for the first time in position to consider the question with advantage.

The desquamation of the cuticle, which almost invariably takes place after scarlatina, and the desquamation of renal epithelium, which not unfrequently occurs after this disease, as well as in acute dropsy, have been supposed to result from a tendency upon the part of the skin and kidneys to "eliminate" the scarlatina poison; and it has been held that these circumstances indicated *an effort on the part of nature* to remove or "eliminate" a noxious poison from the system. But it has not been shown whether the poison is capable of being eliminated, nor proved that it cannot make its own way out of the blood without the agency

of any epithelial or other cells at all. On the other hand, I think it must be admitted that the facts, viz., the peeling of the cuticle and the removal of renal epithelium, might be explained on the supposition that the "poison" had damaged the cutaneous and renal epithelium, as we know it often damages other tissues, and had afterwards made its own way out of the blood. Not only so, but if we accept this view we have a simple explanation why the injury done does not make itself evident till two or three weeks afterwards. The growth of the young cells, *which were at the time of the fever near to the vessels,* was affected, but the interruption of regular growth could not become manifest till the time had arrived when these cells should have considerably advanced in growth and reached the free surface of the body.

So far, therefore, from the desquamation of cuticle after scarlatina being due to an effort of nature on the part of the epithelial cells to *eliminate poison,* it is more probable that scaling results from the young cuticular cells having been damaged by the poison, as it escaped from the blood coming into contact with, and perhaps invading the structure of, these young cells.

But can the hypothesis which assumes that such poisons as those of small-pox and scarlatina are "eliminated" by the skin and kidneys, and that it is the business of the skin and kidneys to eliminate "poisons" of this class from the blood be sustained? If such a

view is justifiable at all, it can only be on the ground that the "poisons" of small-pox and scarlatina are allied to the soluble excrementitious substances, which it is really the business of the secreting organs to "eliminate" from the blood. Recent researches here recorded, so far from favouring this view, lead us to a different conclusion. On the one hand, many things which were supposed to exist preformed in the blood, and to be "eliminated" by the agency of cells, are actually formed by the cells, and did not pre-exist in the blood; and, on the other hand, we have been led to the inference that the "contagious poisons" are totally distinct from excrementitious matters, that they are "living," and quite distinct in their nature from anything that can, as far as is known, be "eliminated." The term "eliminate" is therefore wholly inappropriate. If an epithelial cell can attract towards it, and then get rid of, any kind of living matter, it is an operation concerning which nothing whatever is known. It would not be more incorrect to talk of the "elimination" of ova or spermatozoa than it would be to speak of the elimination of living pus corpuscles or disease germs.

Although it has been asserted that pus corpuscles pass through epithelial cells, it need scarcely be said that the assertion has never been proved, while many arguments that might be advanced render such an hypothesis untenable. But even if the pus corpuscle *did* pass into an epithelial cell, it would not be correct

to say that the epithelial cell *eliminated* it from the body, unless it had been shown that the epithelial cell in some way attracted or drew towards itself the corpuscle. But we know that the pus corpuscle is itself living ; it can destroy epithelium and normal textures, and can make its own way through tissues out of the body. It is opposed to all that we know of the changes effected by epithelium to conclude that it is capable of *attracting* or selecting particles of living matter from the blood and eliminating them.

Moreover, it has been established that living particles of the nature of pus may insinuate themselves into the interstices between epithelial cells, invade these, and ultimately destroy them. The epithelial cells of the mouth are invaded by vegetable germs, but it would surely be absurd to say that the latter organisms have been "eliminated" by the cells, for they simply make their way into the formed material, just as many of the lower animals bore their way into the old tissues formed by some of the higher animals and consume them. It would be as unreasonable to attribute destructive operations depending upon the invasion of the living particles to a tendency upon the part of the cells invaded to eliminate the particles, as it would be to argue that the invasion of the organism by the germs of entozoa was due to a tendency on the part of the body to attract these germs from other bodies, or eliminate them from the surrounding medium.

The term "elimination" has, then, been applied to

two very different phenomena—*the removal of non-living excrementitious matter from* the blood by the agency of epithelial cells, and *the passage of living particles through the capillary walls,* in which operation it has not been proved that the cells take any part whatever. In the first series of phenomena it is reasonable to conclude that the gland cells are the active agents, and not only take up but change materials which they have absorbed ; in the last it is much more probable that the particles of the poison or virus in the blood move themselves, and pass of their own accord through the vascular walls. So far from being selected or attracted by the epithelium, it is more likely that they bring about conditions which damage it, and in some cases lead to its destruction.

Indeed, when we examine the seat of actual change in small-pox, so far from finding the cells imagined to be the active agents in eliminating the poison in a condition such as we should suppose would be favourable to the operation, we find them terribly deranged, many of them completely destroyed, and the particles which are probably "*contagious*" amongst them, dislocating them from their natural positions and damaging them. It would seem that the epithelial cells had been destroyed by the poison, or by the conditions resulting from its presence, rather than that they had selected it from the blood and taken an active part in removing it from the system.

But if the passage of one kind of living matter

through the vascular wall be due to an eliminative act, it is difficult to see why the passage of other kinds should not be due to elimination. If the escape of the virus of small-pox or scarlatina from the blood be an example of "elimination," surely the migration of an entozoon might be referred to the same process, and we might correctly speak of the "elimination" of a leaf from the branch, or the "elimination" of a hair from the hair follicle.

In the organism certain kinds of epithelium are concerned in absorption, and certain kinds in secretion and elimination. In the first the direction of the flow must be *towards* the blood, and in the last *from* the blood. It is obvious that if epithelium ordinarily concerned in *absorption* is to take part in *eliminating* matters *from the blood*, its action must be reversed. The columnar epithelium covering the villi is a remarkable instance of the first form of epithelium, and yet not only has it been inferred that this was concerned in eliminating poison *from* the blood in cholera, but that there was actually an increased formation of epithelium in this disease, and that the detachment of the epithelium was to be regarded as evidence of a tendency upon its part to separate a poisonous material which had been accumulating in the blood. It was shown, however, in the first part of this section, that epithelium usually eliminates without being detached or destroyed, and that we are not justified in inferring that such epithelium could

under any circumstances increase so rapidly as has been supposed to be possible.

But is not cholera characterized by an almost complete cessation of the eliminative process? Is it not a fact that the organs which ought to be active in eliminating morbid materials are almost passive? So far from taking upon themselves increased duties, they do not even discharge their ordinary work. There is, as is well known, complete suppression of urine for a time, and, although there are often profuse perspiration and free discharge of fluid from the intestinal surface, it seems more probable that this increased pouring out of fluid is a physical process, than that it results from an effort upon the part of any cells connected with these surfaces to eliminate matters, noxious or otherwise, from the blood.

So far from the detachment of epithelium in cholera being evidence of an effort of nature to eliminate poison from the blood, it is more probable that it results from a destructive process altogether, and is due to morbid changes which have taken place in the blood in the subjacent capillaries (p. 185). The villus is destroyed and incapable of absorbing or eliminating, and there is reason to think that before the epithelium is detached the circulation, but very imperfectly carried on for a long time previously, entirely ceases. Nothing, therefore, could be brought to the villus for elimination, supposing it were able to eliminate.

I will now venture to state briefly the principal conclusions arrived at in this section :—

1. That the gland-cell is not, as a general rule, destroyed when it secretes.

2. That the poisons "eliminated" by the skin and kidneys are probably in a state of solution.

3. That the poisons of contagious diseases are not soluble, but consist of living germs which move of themselves, but which cannot be "eliminated" from the blood by epithelial or other cells.

4. That so far from there being any evidence of the epithelial cells eliminating contagious poisons, the living particles of the latter interfere with the action of the cells, and many are destroyed by them.

5. That the function of the columnar epithelial cells is to draw substances *from* the intestine and pass them on towards the blood, and that therefore it is most improbable that these cells should take part in "eliminating" anything whatever *from* the blood in health or in disease.

The passage of Disease Germs through the Vessels.— The observations made in the preceding sections will prepare the reader for the remark that the minute particles of bioplasm which constitute disease germs, after having multiplied in the capillaries through which the circulation had completely ceased and made their way into the surrounding tissue and multiplied there, would easily pass in the intervals between epithelial cells and thus reach the free surface ;

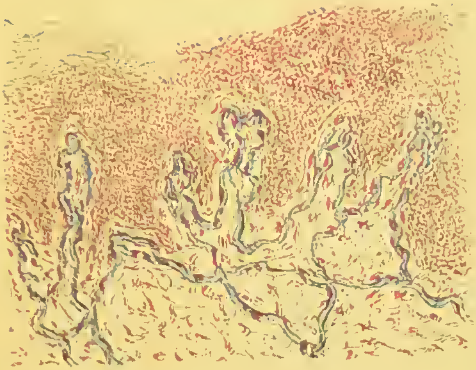
or they might grow and multiply amongst the epidermic cells or epithelial cells of mucous membrane, and cause small collections or flakes of these to be detached from time to time. It is probably in this manner that the poison of scarlatina is discharged from the infected organism. Protected by the scales of cuticle amongst which it has grown, it may retain its vitality for a length of time.

From animals which have died of the cattle plague, I have been able to obtain specimens which show very conclusively the manner in which the escape of the particles of contagious bioplasm is effected. In Plate XXVII are represented several papillæ from the mamma of an animal which died of the disease. All the capillaries contain the bioplasm which makes its way from them into the epithelial texture above, in the manner represented in the outline drawing, Fig. 110. In 113 many of the bioplasts are actually seen amongst the epithelial cells. The bioplasm of the cells is also enlarged from the accompanying fever and inflammation, and in some cases pus was almost produced, Fig. 111. See also pp. 190, 218. Among the softened and altered cuticular cells sporules of fungi may often be detected, Fig. 112, but these have nothing whatever to do with the disease.

The constant phenomena of Fevers and Inflammations.—Although the subject of fever and inflammation is far too extensive to be discussed here, my work would be incomplete if I omitted to refer

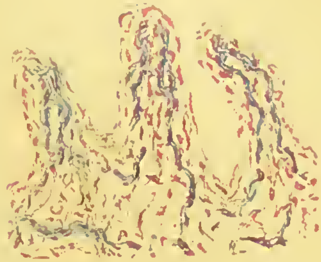
ERUPTION—CATTLE PLAGUE.

Fig. 108.



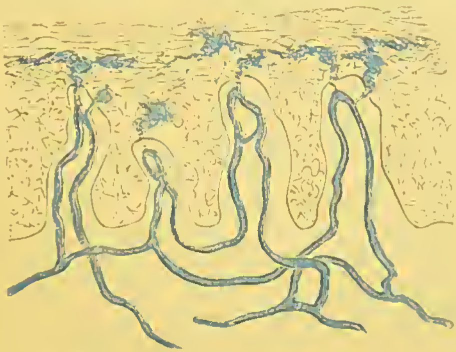
Section through cuticle and cutis in the seat of the eruption cattle plague, showing at *a* a papilla, the cuticle over which is still in a healthy state, whila that above the papillæ at *b* is undergoing disintegration caused by the growth and multiplication of contagious bioplasm among the cuticular cells, as shown by the dark patches. × 130. p. 214.

Fig. 109.



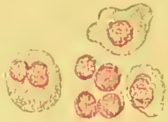
Papillæ from beneath the eruption. Cattle plague. The cuticle is much more easily detached from the cutis than in health. × 130.

Fig. 110.



Outline plan showing how the contagious bioplasm may pass from the capillaries and reach that part of the cuticle where the layers of cells are parallel, *a*, whence it spreads horizontally in various directions, and thus strips off the superficial layers of the cuticle. p. 214.

Fig. 111.

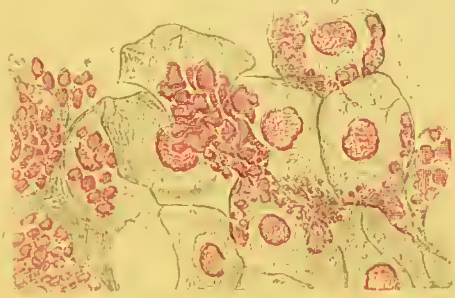


Young cuticular cells and masses of bioplasm growing and multiplying under scab. Cattle plague. × 700. p. 214.

Fig. 112.

Minute spores of fungi amongst the superficial cells of cuticle situated near the eruption. × 1,800. p. 214.

Fig. 113.



... under ... Cattle plague. Eruption on mamma, showing how the cells are ... the ... of the minute particles of contagious bioplasm. × 700. p. 214.

$\frac{1}{1000}$ of an inch × 700.

$\frac{1}{10000}$,, ,, × 1800.

[To face page ...]

altogether to the febrile action which invariably follows the introduction into the system of every kind of contagious germinal matter, and is indeed a constantly attendant phenomenon.

But fever, as is well known, may be due to changes induced within the organism, and which do not depend upon the introduction into the body of disease germs or other particles from without. If in these cases of idiopathic fever there be a *poison* at all, the special morbid bioplasm must necessarily have been *generated* in the organism itself during or just previous to the illness. In the simple feverish state, and in febrile conditions induced by the introduction of contagious bioplasm from without, we find the essential phenomena identical. These are to be noticed: altered chemical changes, impeded capillary circulation, and elevation of temperature, which is maintained as long as the fever lasts. These phenomena cease when free action of the skin, kidneys, and bowels occurs. By this free action, is effected the removal of a large quantity of imperfectly oxidized compounds which had been accumulating during the continuance of the febrile condition. The escape of these substances is soon followed by complete disappearance of febrile symptoms and return to the healthy state. The most virulent and fatal fevers excited by the introduction of poisonous disease germs into the organism differ from the simple feverish condition only in degree, and in the immediate exciting cause of the early changes.

Fever and inflammation are always characterized by an elevation of temperature varying from one or two, twelve, or even fifteen degrees, above the normal standard. If this is not, as I believe it to be, a consequence of the increase of bioplasm or living matter in the organism, the two phenomena are invariably associated. Principally and primarily there is increase of the bioplasm or germinal matter of the blood and of that in the capillary vessels, but afterwards that of the tissues undergoes the same change. This increase of germinal matter is itself due to the presence in the blood of pabulum, and its accumulation in undue proportion. The constituents of this pabulum ought to have been eliminated by various glands as fast as they were formed, or other compounds should have been produced instead, which being more highly oxidized would have been readily got rid of in the form of urea, uric acid, carbonic acid, and other substances easily excreted.

In a common cold, and in any slight feverish attack from which we may suffer, there is evidence of increase of the germinal matter in the blood, of consequent impairment of free circulation through the capillaries, and of increase of the bioplasm upon various mucous surfaces. These phenomena are accompanied by a temperature higher than the normal standard.

Congestion in many of the surface capillary vessels is invariable in all fevers. Upon local or general dilatation of the small arteries and capillaries of the

cutaneous surface, the general redness, spots, or rashes, characterising various kinds of fever, depend. In some cases the dilatation and congestion of the capillaries pass on to actual rupture and extravasation of blood, and little ecchymoses result. In others serum, containing much red colouring matter of the blood, permeates the walls of the vessels and infiltrates the neighbouring tissues. In all febrile states the heart cannot drive the blood through the obstructed vessels fast enough to carry off the animal heat which is developed. The temperature of the whole body therefore rises, and the action of the various organs which are adapted to work perfectly at one fixed temperature is deranged.

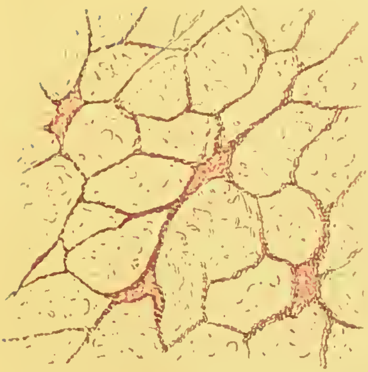
In contagious fevers these same phenomena are observed, and are caused in the same manner, but the bioplasm matter (disease-germs) which increases has a definite rate of multiplication of its own. It goes on increasing for a time, and from its increase serious complications may result. Numbers of the germs produced may pass through the capillary walls into the tissues around, and many escape from the excreting surfaces into air or water, and thus the scourge is spread far and wide. When this has happened, under favourable circumstances the process stops. Products resulting from the death and decay of the specific contagious germinal matter which yet remains are removed by the increased activity of the organs of excretion, and health is gradually restored.

If, on the other hand, the changes have proceeded to a degree sufficient to prevent the capillary circulation over a considerable portion of the body or throughout the greater part of one or more organs, the integrity of which is necessary to life, recovery is no longer possible, and death must result.

The actual changes which take place in the vessels and tissues will be understood if the reader will attentively examine the drawings in Plate XXVIII, which well illustrate the striking alterations which occur in the bioplasm or germinal or living matter of the tissues and vessels in fever. Figs. 114 and 115 represent respectively the bioplasm of connective tissue in health, and in fever. The amount in the diseased connective tissue is many times greater than in the healthy specimen. The masses of bioplasm of the capillary represented in Fig. 116, are more than three times as large as they would be in a state of health, and the same remark applies to the little artery represented in Fig. 117. In both these figures the bioplasm is already beginning to divide and subdivide, and had life been prolonged for a few days, numerous separate particles, like pus-corpuscles, would have resulted. In very bad cases of fever which are fatal, similar changes may be demonstrated in the textures in all parts of the body; and in every case of local inflammation precisely corresponding phenomena are found at the seat of pathological change.

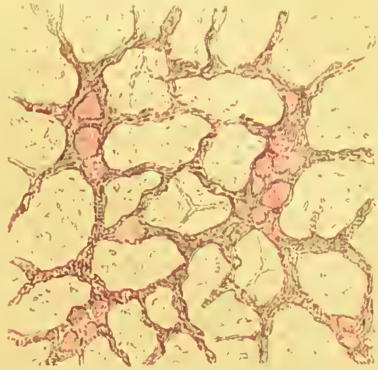
The rise in temperature, be it restricted to a part

Fig. 114.



Connective tissue corpuscles. Surface of healthy mucous membrane over epiglottis just beneath the epithelium. Ox. For contrasting with Fig. 115. × 700. p. 218.

Fig. 115

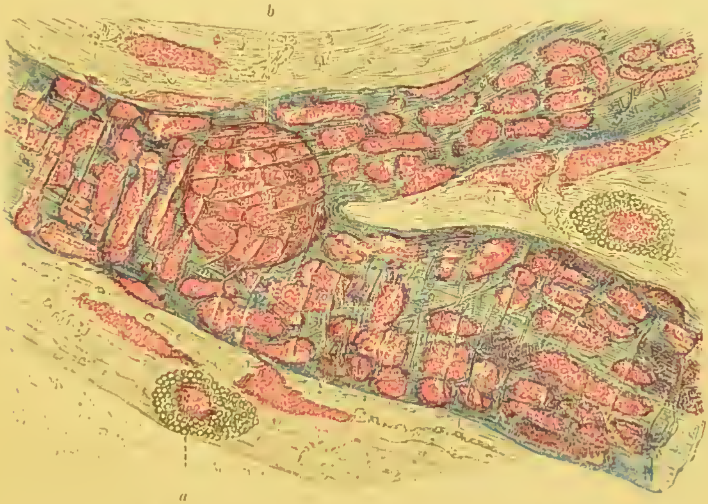


Enlarged connective tissue corpuscles. Surface of mucous membrane over epiglottis—cattle plague—just beneath epithelium. × 700. p. 218

Fig. 116.

Capillary from same situation as the artery, Fig. 117. The masses of bioplasm of the capillary are very much enlarged, and are dividing and subdividing to form new masses. × 700. p. 218

Fig. 117.



Small artery from connective tissue beneath depression of mucous membrane of fourth stomach. Cattle plague. *a*, small cells with numerous oil globules in the external coat of the vessel; *b*, a large mass of bioplasm obstructing branch of artery. × 700. p. 218

of the body, as in *inflammation*, or distributed over the entire organism as in fever, is *invariably associated with the increase of bioplasm.* The facts I have observed justify me, I think, in concluding that whenever bioplasm increases, the evolution of heat takes place. Normally the heat developed is very soon distributed over a wide extent. The arrangements for effecting the distribution, and thereby occasioning the equalization of the temperature in all parts of the body, notwithstanding considerable local variations are, in man and warm-blooded vertebrata, wonderfully perfect. In fever and inflammation the arrangements are much disturbed, or they are completely suspended for the time. In cases where the body-heat rises several degrees in the course of a few hours, the germinal matter or bioplasm increases with marvellous rapidity. The capillaries of a great part of the body are found to be gorged with particles of living matter, for the most part descended from the colourless blood-corpuscles, while the masses of bioplasm of the neighbouring tissues have increased to twice their normal size.

It has been affirmed, over and over again, that the elevation of temperature is invariably due to increased oxidation ; but the state of things above referred to can hardly be favourable to this process. The oxidation theory is quite negatived by the fact that the temperature sometimes rises most rapidly for some hours *after* death has occurred, and when,

it need scarcely be said, the organs concerned in effecting oxidation have completely ceased to act.

The development of animal heat probably occurs at the moment when non-living matter becomes living—when the elements of compounds are separated from one another to enter upon that state of suspended affinity or equilibrium in which they seem to be retained while the living state lasts.

It is of the greatest importance in treating cases of fever, to favour to the utmost the actions concerned in carrying off heat during the persistence of the febrile condition. Although direct cooling of the surface will bring down the temperature of the body, it must not be forgotten that the phenomena upon which the development of heat depends cannot be influenced by this proceeding. On the other hand, by keeping the surface of the body warm and well covered by light woollen things, the operation of the natural process for lowering the temperature is favoured; for when the surface is kept warm, the arteries of the skin are dilated and much blood is brought to the cutaneous capillaries where free evaporation takes place, and much fluid is in this way removed in the state of vapour charged with heat.

Mr. A. B. Garrod has shown that when the clothes are removed from the body and the surface chilled, the cutaneous arteries are caused to contract. The blood is thus diverted from the surface of the body to internal parts so quickly and so decidedly that its

temperature rises, and the mercury in a thermometer placed in the axilla stands as much as two degrees of Fahrenheit's scale higher than it did immediately before the clothes were removed (Proceedings of the Royal Society, No. 112, 1869*).

We have seen, then, that in all feverish and inflammatory states, whether caused by changes commencing in the system itself, or by special living disease-germs introduced from without, important alterations are induced in the blood. An undue amount of nutrient matter is formed, and this is taken up by the bioplasm of the blood of the

* Mr. Garrod has more recently noticed the interesting fact that as the temperature of the external air increases, the rise in body heat on stripping off the clothes decreases. This is a necessary deduction from the theory that the temperature of the body is modified by alterations in the amount of blood distributed to the skin in consequence of alterations of arterial tension. Several observations have been made by him with the view of ascertaining the point at which no change in the internal temperature results from stripping, or what temperature of air causes no rise in the arterial tension. This point has been found to be 70° F., above which, the first effect on becoming nude is a slight fall from the evaporation of accumulated surface moisture, this soon ceases, and the temperature returns to near its previous height. By means of an hygrometer, constructed for the purpose, Weyrich (Die unmerkliche Wasserverdunstung der Menschlichen Haut. Von D. Victor Weyrich, Leipzig, 1862), has found that from many degrees below, up to 70° F. of the external air, the amount of moisture exhaled from the skin does not vary ; but above 70° F. it commences rapidly to increase,—in other words, from that point the sweat glands commence more active secretion. This fact tallies exactly with that ascertained by the use of the thermometer internally. And it is interesting to notice that by these two very different methods of investigation, entirely independent of one another, results are obtained which do not differ by as much as 1° F.

vessels and of the tissues, as well as by the contagious bioplasm when this exists in the system. The increase of the bioplasm in the blood (white blood-corpuscles and minute particles of bioplasm) has been already described in Page 123, plates XII, XIII, *et seq.*

The above changes are invariably associated with increased development of animal heat, which in its turn further favours the growth of the bioplasm.

This interesting subject will be further discussed in a work "On Inflammation and Fever," which will be published shortly.

The manner in which Disease Germs may occasion Death.—The observations already made in this work will have prepared the reader for the inference that disease germs, consisting of living germinal matter, or bioplasm, may be instrumental in causing death in different ways, and in different periods of time, but that in all cases the fatal result is brought about by changes in the composition of the blood, and by serious disturbances in the circulation thereby resulting. The manner in which death begins at the head, at the heart, and at the lungs has been well described; but death may really be said to begin more frequently at the capillary vessels than at any higher texture.

Complete interruption, or sudden cessation of the circulation, from any cause whatever, may produce almost instant death. Fainting, as is well known, results from a more or less sudden reduction of the

impelling force by which the blood is driven into the capillary vessels, and this may end fatally. Any local disturbance of the capillary circulation gives rise to various phenomena according to the precise seat of the change. Interruption of the capillary circulation, over even a small area, in part of a tissue or organ, may lead to the death of that part. In this way boils, and carbuncles, and sloughs are produced, and when the area is extended, mortification of a considerable portion of tissue, it may be of a considerable part of a limb, is occasioned. Partial interruption of the capillary circulation may give rise to inflammation only, as has been described in pages 122, 123 ; and in many cases, even though a considerable portion of tissue may be affected, if only a few capillaries here and there continue to transmit blood, mortification is averted, though inflammation very damaging to the part may result.

In fevers, as has been already mentioned on page 179, the degree of severity of the attack is determined by the extent of capillary circulation which is implicated, and the force of the heart's action. The capillary circulation being equally involved in two cases, in one the force of the heart being very good, in the other very weak, death may result in the latter and complete recovery in the former. The heart's action being weak, it is reasonable to suppose that if by artificial means its force could be increased for the time, the prospects of recovery would thereby be-

come much enhanced. In certain fevers the disease germs may increase in the blood to such an extent during the period of incubation, that the rigors and vomiting which mark the commencement of the actual fever may be followed by death in a very few hours. In some of these terribly fatal cases, it is possible that the capillaries of the nervous centres may be the seat of obstructed circulation; in others the fatal result may be occasioned by rapid chemical changes set up in the blood, and an indirect effect upon the nerve centres produced through the nerve fibres distributed to the capillaries; but in some instances the state of the capillary circulation in all parts of the body justifies the inference that the fatal result is actually due to the cessation of the circulation in the obstructed capillary vessels distributed everywhere.

In fatal contagious fevers, death more commonly occurs some days after the commencement of the attack, and may be ascribed to the obstruction to the circulation caused by gradual plugging of capillaries in every part of the body, consequent upon the multiplication of the contagious bioplasm, and the changes resulting from this phenomenon. The process has been already described in pp. 121 to 126, 179 *et seq*, and the indirect consequences have been referred to. In many instances I have carefully studied the several changes in the capillaries of various tissues of the body, and in a most instructive case of glanders, I

had an opportunity of demonstrating every degree of capillary obstruction in the pulmonary tissue. In the early stages of this most fatal form of fever, boils and other evidences of complete capillary obstruction over a limited extent of tissue are often observed, but these are too frequently followed by more extensive general capillary plugging, which is necessarily fatal.

Of the manner in which an Organism may be "protected" from other attacks of the same Contagious Disease.—Of all the problems I have ventured to touch upon in my book, this is by far the most difficult. It is one which has been as yet little considered. Indeed, until a clear idea of the nature and mode of action of disease germs had been formed, the consideration of such a question could not have been undertaken with much prospect of success.

Certain physicists and chemists, satisfied that all the phenomena of the universe are to be explained by physics and chemistry, would, of course, dismiss this and other such questions in a sentence or two about collocations and physical attractions, molecular properties and evolutional heterogenity, and assure the public that they understood all about it, although they are quite unable to explain what they mean by the long words they employ. A phraseology which is eminently fitted for conveying information about the actions and reactions of lifeless particles upon one another may become utterly devoid of meaning when applied to living things. As long

as such persons hold, contrary to all reason, that the *living* differs only in degree from the *non-living*, in fact deny that there is any *absolute difference* between a thing living and the same thing dead, they will fail to appreciate or to understand vital phenomena ; and, so far from assisting the progress of biology their misdirected efforts only too effectually retard it.

The action of disease germs in the organism is in every essential particular, utterly unlike the action of any non-living substance whatever, for there is no example of the non-living growing and multiplying a million fold, and leaving a state of things totally different from that which existed before the remarkable changes induced by its presence commenced. A living disease-germ of a certain kind is introduced into a healthy organism. It grows and multiplies freely, and in the process causes derangement of most of the normal phenomena, and brings about a state of disease more or less serious. After a definite time, the countless multitudes of germs cease to multiply further. Many of them die, and the products of their decay are eliminated from the body, while many may escape in a living state from the organism and gain access to other living beings. But the remarkable fact is that after an organism has been the seat of these changes, its state is everywhere completely altered, inasmuch as similar disease germs, and in some instances germs of another kind, will no longer grow and multiply. The living particles may get

into the blood, or they may be forced into it, but they will not excite any changes, or at any rate they will not give rise to disease. The organism which has already been diseased and has recovered, may be afterwards inoculated to any extent, but the living particles will not grow and multiply in it. They will die, or if they do not die they remain in the body without inducing any change. The organism which may have been scarcely deranged or nearly destroyed by the first invasion is by that operation rendered proof against a second attack, but this protection is not, at least in many cases, necessarily permanent. After the lapse of a certain period of time, further change occurs, and the organism again becomes fitted for the growth and multiplication of the same kind of disease germs; in fact susceptible to another attack. This period of protection varies in duration, but is probably pretty constant for each particular kind of disease germ.

Some forms of disease germs not only "protect" the organism from a second invasion of the same kind of germ, but the change induced is an efficient "protection" against allied forms. And there is indeed reason to hope that means may be discovered, perhaps by passing it through the bodies of animals, or in some other way, of rendering the poison milder, without destroying its efficacy as a protecting agent—in fact, that we may produce a mild and harmless disease, in order to "protect" the organism from the chance of suffering and being destroyed by a most

virulent and very fatal form of the same malady. This, thanks to Jenner, we have been able to do daily, as regards the most loathsome of all contagious diseases, for the last seventy years. Would that I could say there was great hope that we should soon be able to discover as efficient means of protecting ourselves from the ravages of scarlatina, measles, whooping cough, and other scourges, as, by vaccination, we protect ourselves from the ravages of small-pox. But although all attempts to find out how this great object is to be achieved have failed, we may feel sure, not only that this is possible, but that it will be done. In this direction our work should be unremitting. The secret may be found out any day by the sagacity of a Jenner, or it may not be discovered until long series of carefully devised scientific experiments have been performed, and have for years proved so barren of results that persons well versed in knowledge ridicule those who persist in making them, while the public scoffs at the sacrifice of labour, and becomes indignant at what in their eyes is a most unjustifiable waste of money.

But who would not be struck at the discovery of the fact, if a few animals in a herd were found to be proof against the poison of cattle plague? And who acquainted with such a circumstance would not desire to learn the cause of this immunity from a disease which seizes upon almost every individual animal exposed to its influence? One cow lived amongst the cattle plague

poison for weeks, and was inoculated with it, but never took the disease. Whether this animal had had a mild attack before, or whether her escape was due to some other circumstance, was not determined. But ought we not to work to find out how to induce such a disease mildly in other animals? Will the public neither supply us with the means to discover, on condition that if the discovery be made it be given freely to the world, nor offer a reward sufficiently large to encourage an observer to risk all he has, and spend many years in the prosecution of what may turn out to be an absolutely barren investigation? Many a scientific man would work for the best years of his life for the value of one monster gun, and many valuable investigations might be conducted for a sum equal to that spent upon a single discharge.

In cases where "protection" has been obtained, the change effected in the organism, it may be remarked, is general and complete. The entire mass of the blood is in some way altered, and there is not the smallest particle of the body which is not efficiently "protected" against invasion by certain special disease germs. The result may be explained by supposing that changes have occurred in the blood only, without any alterations having been necessarily effected in the solid tissues. All contagious fevers are, in fact, essentially *blood diseases*, so that in discussing the nature of the changes which may be instrumental in effecting "protection," we may con-

fine ourselves to the consideration of the manner in which the blood is probably altered. Although the precise nature of the alteration induced cannot be determined, it may be worth while to consider which of several changes that may be caused by the growth and multiplication of the disease germs is most likely to be the actual change which is occasioned.

In the first place, some substance existing in the blood prior to its infection may be taken up, assimilated, and thus removed by the growth and multiplication of the germs. This matter being necessary to their growth, it follows that by its removal from the blood further growth of the germs, should more be introduced, would be prevented, or, in other words, a second attack of the disease becomes impossible.

Secondly, it is possible that by the growth and multiplication of the disease germs in the blood, some new material may be produced which is destructive, and thus, as long as this material remains, further growth is prevented.

Neither of the above suggestions is, however, satisfactory, because the materials supposed cannot be proved to exist chemically; and in order to account for "protection" being only temporary, we must further suppose that the material which we know nothing about, may according to the first hypothesis, recur at a future time, and according to the second disappear.

But, thirdly, it may be supposed that from the par-

ticles of bioplasm which induced the first attack of disease, bioplasts are produced, which continue to give rise to others. As long as this production of new germs by descent proceeds, the bioplasts must take up pabulum, which other disease germs in their absence might appropriate. In this way we can account for "protection" lasting only for a time. When these germs cease to produce descendants, or, producing descendants whose properties gradually change, the state of "protection" ceases. Upon the whole, then, I incline to the view that "protection" is due to the presence of bioplasts in the blood, which have directly descended from those introduced. These, growing and multiplying in the blood, take up the pabulum suitable for the nutrition of disease germs, and the growth and multiplication of the latter and of germs allied to them in character is prevented, should any such gain access to the blood.

While "protection" lasts, we may infer that the growth and multiplication of the protecting particles interferes with the growth and multiplication of the virulent disease particles. After a time, however, the descendants of the first becoming exhausted, the last may then be victors in the struggle for existence.

OF THE NATURE OF THE CONTAGIOUS DISEASE GERM.

Contagious Disease Germs not Parasites.—Many different things, the characters of which are not very clearly defined, and not to be easily determined, are often called by the same name, and it is perhaps not to be wondered at, considering the serious difficulties encountered by scientific investigators in their attempts to discover the real nature of the contagious disease germ, that this virulent particle should, as it were, by common consent, have received the reproachful designation, "parasite." But it is much easier to call a thing a name, and to assert that it belongs to a particular order or class of things, than it is to demonstrate its affinities, and assign good and sufficient reasons for the nomenclature and classification adopted. There are some objections to the view of regarding disease germs as parasites, which do not appear to have presented themselves to many of those who have used the word. Some have indeed tried to give to it a wider and more extended meaning than can be justified, and thus have included in the parasitic class many living organisms that ought not to have been consigned to so questionable a position.

The doctrine of the parasitic origin of contagious disease has no doubt received some support from the circumstance that certain morbid affections have

undoubtedly been shown to be associated with the presence and vigorous growth of organisms belonging to the class of parasites; but of late the term parasite has been used far too freely, and the word has been employed without due consideration. Not only have the living particles of mucus and pus been thus designated, but the highest living cells in the body of man himself have been called parasites.

Scientifically speaking, a parasite is an organism which lives upon another organism. The organism does not evolve the parasite any more than the latter produces its host. The organism may live in the absence of the parasite, though for the latter to exist the first is a necessity. The parasite is a descendant of a pre-existing parasite—not an emanation from the being upon which, and perhaps by which, it lives. A vegetable or animal organism dependent for subsistence upon the juices or secretions of another vegetable or animal organism much higher in the scale is a parasite. But it is as wrong to speak of the constituent living growing cells of the human body as parasites, as it would be to assert that the complex individual compounded of them was a parasite.

Every cell of the organism has been formed by direct descent from the original embryonic mass of bioplasm. The bioplasm of each cell is capable of growth and multiplication, but it cannot be looked upon as parasitic upon other cells, for its parentage is the same as theirs. For the same reason abnormal cells cannot be

regarded as parasitic upon healthy cells, although many forms of abnormal bioplasm, like pus, cancer, &c., may be transferred from animals to man, or *vice versâ*, and grow and multiply. All such forms have, however, been derived from normal cells, which perhaps would not grow and multiply if transferred from one organism to another, though all have descended from the same primitive bioplasmic mass. As the bioplasm retrogrades it acquires the power of living upon less elaborate pabulum than normal bioplasm, and may even appropriate different kinds of pabulum. Its rate of growth and multiplication is far greater than that of the normal bioplasm from which it came, and it retains its vitality under circumstances which would certainly have ensured the destruction of the latter. Nor must the fact be lost sight of that the development of the abnormal forms of bioplasm tends to degradation and destruction. The bioplasm of vaccine, although conservative in effect, is damaging in its action. Its growth is the lesser of two evils. But these and allied forms of bioplasm cannot be considered parasites on account of their derivation.

The true parasite is as much a species as is the being upon which it feeds. The masses of living matter developed from the living matter of one of the higher organisms have descended from a specific living mass. In no sense can such bodies be regarded as species. Never do they regain the properties and powers of the living matter from which they were

derived—never do they give origin to descendants having such properties and powers. On the other hand, every parasite is complete as an organism, and gives rise to organisms like itself, which may repeat its life history. A parasite possesses individuality, but a disease germ can no more be regarded as an individual than a white blood corpuscle, or a pus corpuscle, a nail, a hair, or a gland follicle can be so considered ; for, from any of these, under no known circumstances can a complete individual organism be developed. If such bodies as mucus corpuscles, pus corpuscles, cancer cells, tubercle corpuscles, and disease germs generally, be termed parasites, the nails, or hairs, or glands, or limbs might with equal propriety be regarded as of this nature. Even the brain cells have been spoken of as parasites, but one would have thought that if any part of the body of a man belonged to him his brain cells were certainly his own, and therefore could not be parasites living upon him. Such confusion has resulted, that it is really difficult to decide what is a parasite ; and it seems almost vain to hope to restore the scientific meaning of a term which has been entirely metamorphosed by the sparkling wit and keen satire of transcendent literary genius.

Nature of Contagious Disease Germs.—Although many diseases are caused by the action of noxious gases, fluids, and solids of various kinds, every one will agree that the particular forms of disease now under

consideration—the contagious fevers—result from the introduction of living particles of some form or other. But of the nature and origin of this living matter opinions differ, and the differences are very decided, and oftentimes are expressed energetically. The subject is intensely interesting, and not second in importance to any kind of enquiry whatever. The view to which my investigations have led me will have been already gathered by the reader (*see* p. 149), but in the present section I propose to recapitulate some of the evidence which has already been adduced, and to reply to some objections which have been raised.

In the first part of this work I have endeavoured to show that the doctrine of the vegetable nature of disease germs must be abandoned. No one has succeeded in proving that any form of contagious living matter can be traced to a microscopic fungus or other low vegetable organism. Nevertheless, in opposition to all that has been urged to the contrary, but without a reply to one of the many arguments advanced against the doctrine, we find the vegetable nature of disease germs, and the prejudicial disease-carrying properties of vegetable fungi, taught and advocated in "The Twelfth Report of the Medical Officer of the Privy Council." As the Report has been published since the first part of this work was printed, I propose to offer a few more remarks upon this doctrine which seems to have a warm supporter in Mr. Simon. I was much surprised to find a general

assent to the views of Hallier, which have not been confirmed and which few who have carefully studied the matter are inclined to accept.

In his report the Health Officer of the Privy Council makes the following remarks upon this subject :—" Knowing that all contagia (as such) are distinct from one another, and believing that each of them has its essence in the so-called microzymes which it contains, we by implication impute to the microzymes that in different diseases they are not identical ; and as we affirm them to be dynamically different, so also we assume that under well devised differential experiments, other signs of their specificity may be brought to light, and for each sort of them a definite genesiology be written." Athóugh many objections have been raised to these and allied views, they appear to be regarded with especial favour in the Government Report. More than a dozen closely printed pages have been devoted to an exposition of Hallier's strange doctrines, and several of his drawings have been repeated in the Introductory Report by Dr. Burdon Sanderson.

Figures of the supposed contagious microzymes have been given, which refute themselves. The drawing given by Dr. Sanderson in his Report (Fig. 1, p. 232), and described as groups of particles in fresh vaccine, conveys no idea of the actual appearance of the matter represented. A few minute circles may be made to indicate very fairly the appearance of

microscopic fungi, but they are no more like the particles of vaccine lymph, or any contagious poison, or any kind of living matter known, than an oil globule or an air bubble is like a white blood corpuscle, or a pus corpuscle. Such illustrations only help to retard investigation and to convey erroneous ideas regarding the character of the matters referred to ; nor is it right to lead the reader to suppose that nothing more has been made out concerning the little particles of vaccine than is represented in the drawing referred to, considering the particles in question were described and figured under a much higher magnifying power several years ago.

But strange to say, Dr. Sanderson remarks that the presence of these particles is in itself a fact of *little importance* (!), because "many transparent organic fluids, as, *e.g.*, the liquor sanguinis, are found when examined under high powers, to contain particles of about the same size as those which exist in vaccine." Now it is quite certain that the fact is of the very highest importance, as showing that *living particles, having precisely the same characters, may differ remarkably in powers and properties*, and that therefore these last cannot be attributed to chemical composition, or to anatomical structure. But the same writer intimates that the opinion may be fairly entertained that bioplasm *might* exhibit structure if subjected to more perfect investigation, and then remarks that the resemblance between different kinds of germinal matter

"relates rather to those properties of which we can judge by anatomical means, than to those of *chemical composition*, or even organic form." Such a remark indicates that the writer does not understand the view he thus attempts to criticise. Neither he nor any one else knows anything about the composition of living matter. Dr. Sanderson's remarks clearly show that he is opposed to the views advanced by me, but if he noticed them at all, in common fairness he ought to have stated exactly what they were. He may do his utmost to make people believe in the old notion that the properties of various kinds of living matter are due to chemical composition, or to organic form, but the facts of the case render such a view absolutely untenable, nor could it have been made to appear plausible had the objections which have been urged against it been stated. No wonder that innocent fungi are again made to do duty for the active particles of contagium, ordinary bacteria, called "microzymes in vaccine" and "crypto-coccus cells" obtained by the "cultivation of vaccine;" for Hallier's "Micrococci" are still regarded as disease-carrying particles, and readers are entertained with the oft-told story of the "rice parasite." Several of Hallier's untenable theories are minutely discussed, whilst the mass of evidence against his conclusions is almost entirely passed over.

If such a subject as the "intimate pathology of contagion" be discussed at all in a Government report,

it is only right that a fair and clear statement of the views of those who have investigated the subject should be given, accompanied by references to the original memoirs. Otherwise by these reports particular theories are promulgated as it were by authority, and instead of the public being furnished with a comprehensive view of what is known at the time regarding questions of the deepest scientific interest, as well as of great importance, they are led to accept inferences which perhaps have long been actually proved to be erroneous. Competent observers have indeed rejected Hallier's conclusions as based upon inconclusive evidence. Moreover the arguments advanced against the notion that the contagious poison consists of vegetable particles are so conclusive, that the abandonment of the theory is probably only a question of time.

It has been shown that the contagious poison of contagious fevers and allied affections is not volatile, nor composed of mere albuminous matter capable of being dissolved in fluid. It consists of minute particles of soft matter in a living state, and as was stated in my Report, printed in 1856, this material increases and multiplies, and behaves in a manner *peculiar to matter which is alive.* Though the contagious disease germ consists of living matter, and is formed in a living organism, and lives and grows in the body, it cannot properly be regarded as parasitic.

Any one who had studied the germinal matter of

the lower simpler creatures, or that of man and animals at an early period of development, or had only cursorily glanced at that which can be seen and studied so readily in the developing textures of a young embryo, or in an inflamed tissue, or in a rapidly growing morbid growth, as cancer, would have been quite prepared for the observation that the living bioplasm of contagious disease presented nothing more remarkable than was to be observed in connection with any other kind of living germinal matter.

In my Report to the Cattle Plague Commissioners these arguments were set forth, and the observations were illustrated with numerous drawings. The contagious material was represented in several of these, and some general conclusions were arrived at, which it is believed were fully justified by the facts and observations recorded. I was therefore disappointed when I read the comments of the Commissioners, and I believe that any one who reads the observations in my Report, and then refers to the remarks of the Commissioners, will come to the conclusion that the writer of this part of the Report was either prejudiced against my conclusions, or that he had not read the observations on which they were based. Although the living poisonous germinal matter had been described and figured, the public were told that I had "found no definitely formed substance that can certainly be said to be the cause of cattle plague," and that I had discovered "granular matter." Not

only were my conclusions misinterpreted, but it was asserted that the method I pursued was not likely to succeed, and that the poison was of a kind which "is and will *always* be undiscoverable by the microscope."

The suggestion of the Commissioners is that the poison consists of some complex albuminoid matter, in a state of rapid chemical change, which causes "an increased zymotic action in the blood and in the textures," but the complex chemical substance has not been discovered, and nothing is known of the rapid chemical changes it is supposed to undergo. A "zymotic action in the blood" requires explanation, while a zymotic action in the textures is simply as inconceivable as fermentation of skin and bones and muscles. The opposition to the use of high magnifying powers which had shortly before been introduced and much employed by me, was very strong at the time the Report was published, and many did not hesitate to insinuate that the conclusions arrived at were due rather to the imagination than to investigation. Since that time, however, so many twenty-fifths have been employed, that it is quite needless to defend their use, while some of those who insisted so much upon the results of physical and chemical experiments have been forced to appeal to the fancy for evidence in support of their theories which were not based upon facts.

The characters of the actual contagious material having been demonstrated in several instances, I do

not think any one will urge as an objection to the general application of the doctrine here taught that these same characters ought to have been proved in the case of every contagious malady known to us. As well might it be argued that we cannot accept any conclusions as to the nature of pus until the pus produced under all possible kinds of pus formation, and in every part of the organism has been submitted to investigation. Knowing what we do of the several diseases, it would not be reasonable to infer that the poison of small-pox consisted of matters in an essentially different state from that of vaccine poison, or that the poison of typhus, typhoid, relapsing fever, scarlet fever, and measles, consisted of matter in very different physical states,—in one fever being a gas, in another a liquid, in one an alkaloid, in another a protein substance, and so on. Such a doctrine would be absolutely untenable. It may, however, be urged by dissentients, that the evidence I have adduced in favour of the contagium of all contagious fevers being a form of bioplasm, is not conclusive, because every individual contagious fever has not been subjected to precisely the same course of minute investigation.

The minute contagious bioplast is less than the $\frac{1}{100,000}$th of an inch in diameter, and often so very clear and structureless as to be scarcely distinguishable from the fluid in which it is suspended. Such a minute particle may readily be transferred from the affected organism to an apparently sound organism.

It may be carried a considerable distance from its source without losing its marvellous power of causing in the organism invaded a series of changes resembling, and often in very minute particulars, the phenomena which have occurred in the organism from which it was derived.

And it is established that there exist different kinds of contagious living bioplasm, each capable of occasioning specific phenomena which distinguish it. The poison of small-pox will produce small-pox, not typhus fever, or measles, &c., nor will any of these produce small-pox.

Without therefore pretending to identify the actual particles of the living bioplasm of every contagious disease, or to be able to distinguish it positively from other forms of bioplasm, healthy and morbid, present in the fluids, on the different free surfaces, and in the tissues in such vast numbers, I think the facts and arguments I have advanced prove—first, that the contagious virus is living and growing matter; secondly, that the particles are not directly descended from any form of germinal matter or bioplasm of the organism of the infected animal, but that they have resulted from the multiplication of particles introduced from without; thirdly, that it is capable of growing and multiplying in the blood; fourthly, that the particles are so minute that they readily pass through the walls of the capillaries, and multiply freely in the interstices between the tissue elements or epithelial cells;

and lastly, that these particles are capable of living under many different conditions—that they live and grow at the expense of various tissue elements, and retain their vitality, although the germinal matter of the normal textures after growing and multiplying to a great extent, has ceased to exist.

But the reader will ask which of the particles seen in the secretions from the nose and eyes, intestines, vagina, and in the tissues, are the particles of *contagium*, for it has been proved that in matter from all these situations, at least in cattle plague, the contagious property resides. He will probably have gathered from the statements made that I regard some of the most minute particles present to be alone the active agents, while the epithelial cells, the fungi and bacteria, are probably as passive as the oil globules or crystals of triple phosphate commonly met with. Particles which I believe to be contagious are represented in Plates XXIV to XXVIII, figs. 95, 97, 100, 101, 105, 107, 108, 113, and the bioplasm amongst the bundles of fibrous tissue, represented in Pl. XXVI, figs. 103, 104, I think consists entirely of particles, the smallest of which would induce the cattle plague, if introduced into the blood of an uninfected animal. Figs. 95, 97, 101, represent particles of the supposed contagium or active contagious matter in the vessels. It would, I think, be quite possible to devise experiments which would determine positively which is the real contagious matter. The real contagious material has passed unnoticed,

having been included in the collection of substances which have been denominated *débris* and granular matter. By the carmine fluid we can, however, distinguish particles of germinal matter from fat granules, myelin particles, and *débris.* Nor are observations and experiments upon this most interesting question concerning the nature of contagium limited to cattle plague. Although this disease affords in very many ways advantages for study far above many other contagious maladies, and deserves on many grounds the most thorough and extended scientific investigation, no doubt many of the questions of the greatest general interest may be successfully worked out by studying other contagious maladies affecting man or animals.

No Difference to be detected in the Appearance of different kinds of Living Matter.—I have shown that even with the aid of the highest powers of the microscope no differences can be discerned between bioplasm from the cell or elementary part of the highest organism at any age or period of development, and bioplasm of which the lowest simplest being in existence is composed. A minute particle of the germinal matter of an amœba could not be distinguished from a portion of a pus or mucous corpuscle, or white blood-corpuscle, &c. Compare Figs. 30, 32. p. 100; 52, 54*, p. 130; 120, 121, p. 148.

It will probably strike many as very remarkable that the highest magnifying powers hitherto placed at

our disposal serve but to convince us that a minute particle of the bioplasm of the most malignant tumour, or the most rapidly growing pus corpuscle, resembles in every particular that we can ascertain by observation or experiment, a minute particle of healthy living bioplasm, from the blood or from any tissue, and it is proved beyond a doubt by the same means of enquiry, that the living particles of bioplasm in vaccine lymph cannot be distinguished from those present in normal lymph or chyle. In short, that no differences exist in colour, form, density, chemical composition, or movements, between living particles producing the most diverse results, and giving rise to the production of the most different substances (formed material). I think we shall find ourselves compelled by the necessities of the case to refer the properties of these different substances to what must be termed *a difference in vital power*. To this we may attribute the different relations of the elements, which must be brought about immediately before they combine to form the different chemical compounds Any argument against my conclusions, based upon the circumstance that no *special* germ can be detected in any contagious diseases, can therefore have no force, and will not be advanced by any one who has made himself acquainted with the facts of the case. All the contagious fevers have many points in common, and for this reason we should naturally infer that the poisons which give rise to them, although distinct

from one another, belong to one class or order of living matter or bioplasm.

As every known living thing consists at one period of a little, clear, transparent, structureless, living, moving matter, which exhibits precisely the same characters in every case, though possessing powers so wonderfully different—as the various tissues and organs of man and animals all result from masses of living matter not to be distinguished from one another except in the results of their life—there is nothing, regarding the matter from this point of view, to deter us from accepting the conclusion to which we are led by actual observation, that the poisons of the different contagious diseases could not be distinguished from one another by microscopical examination or by chemical analysis.

Disease Germs may long remain Dormant, though alive.—Just as a seed may remain perfectly quiescent, but nevertheless in a living state, for a long period of time, without growing or giving any evidence of vitality, so, there is reason to think, many kinds of bioplasm may remain in a living, but almost dormant state, in the system, ready to spring into activity should the conditions favourable to their existence be brought about, and the pabulum adapted for their nutrition be at hand. Unquestionably the morbid bioplasm of certain kinds of tubercle and syphilis may exist for years in a quiescent state. The development of the forms of disease characteristic

of its presence being determined by the state of the system and the conditions to which it is exposed. So that of two persons equally infected, but living under very different, and, in some respects, opposite conditions, the germs in one, after remaining dormant for a long while, may at length die and become extinct, while in the other organism, being placed under conditions favourable to their activity, the germs grow and multiply, and perhaps even destroy the body, it may be at a very early age. And it is possible that in one organism more than one kind of morbid bioplasm may be dormant, the conditions favourable to the growth of one being unfavourable to that of another. So that of many kinds present, one or more may become active. The careful consideration of facts of observation in connection with the subject of contagious diseases, leads to the conclusion that in all cases where disease is developed two things are necessary—1, the presence of the living disease germ ; 2, the external conditions favourable to its growth and multiplication. It seems to me, therefore, that if every disease germ were destroyed to-morrow, the result would probably be far less favourable to humanity than if every organism could be placed under the conditions most favourable for resisting attack, and therefore under circumstances which would interfere with the growth of the disease germ, which at length would die. And for this reason—that in the latter case the extinction of disease germs, although more gradual, would not

be less certain, while the probability of invasion would grow less as time advanced, and the development of new germs would become impossible.

It will probably be noticed that the above remarks are as applicable to the development of normal, as to that of abnormal forms of bioplasm. For multitudes of the lower forms of life spring into activity whenever the conditions favourable to their growth prevail. They may remain so quiescent for months, that no one would believe that their germs were in existence, but in a night the air or water of a district may become peopled with countless multitudes of beings, not one of which was to be found a few hours previously. No wonder the air or the water was supposed to create them, and that the doctrine of spontaneous generation was the belief of the vulgar. It is not a little remarkable that such a view, driven as it has been from one position to another during the last two hundred years, should yet find advocates among the most active intellects of these days. Instead of despairing, its supporters still keep up such a show of vigorous resistance, that the public, judging only from the information afforded by warm advocates of heterogenesis, is led to believe that although a horse, a mouse, a maggot, a worm, a rose, and even a mushroom unquestionably came from living things of the same kind which lived before them, very low microscopic forms, which are only to be seen with difficulty under the highest powers, spring direct from the non-

living, without being indebted for existence to a previous generation.

On the Origin of Disease Germs.—We have now to try to find an answer to some very important questions, among which are the following:—Have disease germs always existed? Is their origin contemporaneous with that of life, or is it more probable they are of more recent date? Could they have existed before man, and independently of man, or is their production necessarily associated with human beings? If the latter appears to be the most probable view, we may enquire further whether there were contagious disease germs in the prehistoric epoch, or if their evolution is in some manner dependent upon civilization. The thoughtful student naturally desires to know if disease germs of each special kind known to us at this time, always retained the characters they now possess, or if their properties have become modified from time to time as external circumstances have changed. Are disease germs ever developed anew in these days? Do generations of disease germs die out and give place to others allied to them, but not identical? And, lastly, the important practical question which has been already referred to in page 249 presents itself. Supposing it were possible to extirpate entirely all disease germs now existing, is there reason to think that new forms of precisely the same kind would be reproduced, or that more or less closely allied forms would be developed anew?

It is not, I think, possible in the present state of knowledge to reply definitely and conclusively to many of these enquiries; but it is well that they should be made. And in considering the mode of origin of contagious living matter, to which subject the present section is devoted, it will be my duty to lay before the reader, as simply as I can, the grounds upon which are based the views I have been led to adopt.

The facts that the living matter of the blood of one individual will live in the blood-vessels of the organism of another; that skin, periosteum, and other tissues may be transplanted and grafted, prepare us for the acceptance of the remarkable circumstance demonstrated by experiment that living pus bioplasts which have indeed been derived from normal bioplasm, may traverse long distances, free and independent, and then, gaining access to another organism, may live, and grow, and multiply in it, and establish changes of the same kind as those which were taking place at the seat of its origin.

Many of the lower and simpler forms of life, as is well known, may continue to grow and multiply as larval or imperfectly developed forms, and attain, under altered conditions, a higher and altogether different state of existence, during which the process of multiplication in that way ceases. It is possible that the exceedingly minute living particles which constitute the "contagium" of contagious

diseases, may be the degraded offspring of some kind of normal living matter or bioplasm, which originally possessed comparatively exalted tissue-forming or other formative powers.

A consideration of many different circumstances leads me to suggest the possibility of the origination of the contagious fever poison in the matter which grows and multiplies in the capillaries in the feverish state. It is not improbable that in certain states of system the minute particles of bioplasm in the blood may grow and multiply enormously, without ever being developed into white blood-corpuscles, just as many of the lower organisms multiply infinitely without one of the offspring necessarily attaining the highest state of perfection possible. The surrounding conditions may be adverse to the individual particles attaining their perfectly developed form, though favourable to their growth and multiplication in an immature state.

The phenomena which occasion the formation of ordinary pus, may, if they continue to occur for a long period of time, determine the development of a specific pus, which has still more marvellous powers of vitality. So it may, I think, be reasonably argued that if the ordinary feverish state be prolonged for a considerable time, and be severe in degree, it is likely that the bioplasm in the blood collected in the capillaries may give origin to bioplasm with marvellously increased powers of retaining its vitality, of growing

and multiplying. The particles of this, making their way through the vessels, and escaping, may live for a considerable time, and having entered the blood of another person, may excite in it changes which accompanied their own development.

Now, an organism which is about to be the subject of an ordinary feverish attack, would probably, if exposed to the influence of contagious disease germs, become the seat of development of a specific and perhaps fatal contagious fever. It is only reasonable to infer that a state of things favourable to the rapid growth and multiplication of disease germs, is not very different from the conditions favourable to their origin.

It has been already shown that the living pus-corpuscle and the living disease germ, like every other kind of living bioplasm, have been derived from pre-existing living matter, and it would not be difficult to suggest certain "laws" by which the retrograde evolution of the bioplasm might be said to be governed. But of late so many "laws" have been made, that it is not desirable to attempt to make any new ones. If, at this present time, there is an intelligence sufficiently perfected to reveal to us what kind of new disease germs evolved under the then altered conditions of society will afflict civilized man three centuries hence, and what sort of new contagious diseases they will necessarily excite, it is doubtful if, with the limited powers of understanding with which most of us are

endowed, we should be able to recognize the importance of the discoveries of a scientific imagination so exalted, or appreciate the "laws" it had evolved for our instruction. Without, therefore, venturing to state positively from what particular kinds of germinal or living matter of the body the germs of contagious disease are actually derived, or attempting to decide definitely whether they come from the very minute blood bioplasts, or from ordinary white blood-corpuscles, or lymph corpuscles, or mucus, or epithelial or other particles, I think I am justified in advancing the doctrine that the germs originate in man's organism, and that they have descended from the normal bioplasm of his body.

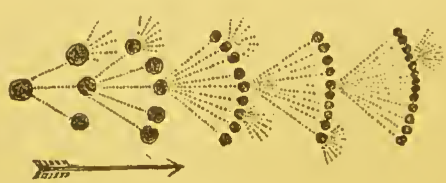
In ordinary febrile states, the bioplasm of the blood is increased, and it is not improbable that from the growth and multiplication of this bioplasm, under certain circumstances, contagious bioplasm of various kinds may result.

It would seem, then, arguing from the facts referred to when discussing the inflammation of the peritoneum, in which process a very highly contagious form of bioplasm is developed in the course of a few hours, that there can be little doubt regarding the origin of the poison in this particular case. The minute particles of bioplasm or living matter produced in such great numbers as the inflammation advanced, are the actual agents, and it is by their rapid growth and multiplication in the lymph, and afterwards in the blood,

particularly in the capillaries in various parts of the body, that the dreadful effects exerted by these particles in an organism into which some have been introduced by inoculation, must be attributed.

It seems, then, that every stage in the production of at least this particular virulent poison, may be watched and studied, and from the facts ascertained a connected history of its development may be compiled. We have seen that the first particles of bioplasm resulted directly from the bioplasm of the blood. In consequence of continued free access of nutrient material, series after series, generation after generation, of new particles was produced; each series degenerating in formative power, and acquiring new powers, but of mere growth and multiplication, and a capacity for living upon materials which would not have been appropriated by the bioplasm from which it originated.

The following diagram may perhaps assist in rendering my meaning clearer:—



a *b* *c* *d* *e* *f*

White blood-corpuscle. Healthy bioplasm. Formative.

Contagious disease germs. Morbid bioplasm. Destructive.

Successive series of living particles resulting from the growth and

multiplication of a single white blood-corpuscle. Each series grows faster than the one from which it originated. In the plan, the process of multiplication is represented as if it only occurred in the case of one particle in each series ; but in order to afford an accurate conception of the process, similar radiating lines must be supposed to diverge from every part of the circumference of every particle. *a* is a white blood-corpuscle ; *b*, *c*, *d*, and *e*, successive series of particles which produce others, until at last contagious disease germs, *f*, result. In this particular instance we seem to almost succeed in demonstrating the manner in which a very highly contagious bioplasm originates in hospital and camp fever.

In certain forms of erysipelas, purulent ophthalmia, and analogous contagious diseases, which sometimes originate in an isolated population living under certain conditions adverse to health, it is almost impossible to doubt that the living germs are developed in the same manner as the virulent pus bioplasts produced in peritonitis from the bioplasm which was once in a normal healthy state. And the same reasoning leads to the inference that the generation of the poison of many contagious diseases, and all contagious fevers, occurs in the same way. It is certain that many cases of blood-poisoning, and various forms of idiopathic fever, depend upon the passage into the blood, and its dissemination through the system, of a poisonous bioplasm which has been generated in the body, the virulent bioplasm itself having resulted from the growth and multiplication of generations of particles derived by continuous succession from the normal bioplasm of the organism.

In some cases the morbid living matter found in

man will live in the higher animals, and that produced in the latter propagates itself in the human body. As bioplasm becomes more degraded, it acquires an increased capacity of retaining its life under a greater variety of conditions. Pus which is derived from normal germinal matter by direct descent is not so easily destroyed as the germinal matter from which it proceeded; and special kinds of pus, which are separated from the bioplasm of health by a vast number of intervening generations, possess, if not a still more remarkable tenacity of life, at least the power of living under a greater variety of conditions. It is therefore possible that means may be discovered of destroying the life of these different forms of adventitious bioplasm. Being naked, that is, unprotected by any cell wall or formed material, these bioplasts are exposed to the direct influence of any vapours or fluids which may be brought to bear upon them, while, on the other hand, the bioplasm of the tissues would resist the action of these same agents, in consequence of the efficient protection afforded by the formed material around it. The naked germinal matter of the healthy blood is probably acted upon by many poisonous substances which do not affect the living matter of the tissues of the body, and there is reason to think that certain poisonous agents, the action of which is exceedingly rapid, destroy life by instantaneously killing the germinal matter of the blood, and thus leading to stoppage of the circulation.

It is from researches in this direction that we may hope to gain knowledge which may lead to the discovery of means of destroying the contagious germinal matter while in the blood, and of preventing the influence of poisons of another kind upon the living bioplasm of the blood, capillary vessels, and of that of the tissues immediately adjacent.

A careful study of the course and symptoms of the various fevers which have been prevalent at different periods, leads to the suggestion of the probability that from time to time new germs are produced, and that old ones deteriorate and disappear. The new forms may be closely allied to already existing forms, and to forms which have existed previously, but nevertheless the results occasioned by their development are so peculiar that we cannot but suppose they are occasioned by a poison of a special kind. It is even possible to discern differences between cases of the same type of contagious fever, which would be sufficient to justify us in arranging them as species of a genus, or as varieties of a species.

It is not probable that disease germs have sprung from insects or animalcules, or any kind of vegetable organism, neither have they originated in the external world, and seized upon man, but they have been derived by direct descent from the normal living bioplasm of the organism. They have originated in man, and if man is not indeed responsible for their origin, he has certainly himself imposed the conditions

favourable to their production and dissemination. Human intelligence, energy, and self-sacrifice may succeed in extirpating them, and may perhaps discover means of interfering with the origin of new forms not known to exist at this time.

PART III.

THE DESTRUCTION

OF

DISEASE GERMS;

AND THE

TREATMENT OF DISEASES CAUSED BY THEM.

THE first object of everyone who aims at the prevention of the spread of contagious diseases, must be to destroy the contagious particles before they can spread far from the organism in which they have been produced. As we know that millions of active germs have grown and multiplied in the body of the sick person, and that up to this time we are powerless to prevent this multiplication, our efforts must be directed to the object of destroying these living particles as soon as possible after they have been formed.

The sick person suffering from contagious disease should be isolated. The nurses and attendants should be as few as possible, consistent with the interests of the sick, and these attendants, for the time, should communicate as little as possible with other persons.

All food and drink which has been in the sick room for some time should be consumed by no one but the sick or by the attendants, and clothes should not be taken away until they have undergone disinfection, or should be carefully removed only for this purpose. Air which escapes from the sick should not be allowed to pass into rooms where healthy persons are living, without being subjected to the influence of some disinfecting agent, or at least largely diluted by admixture with fresh air.

It has been already shown that contagious disease germs are so minute that they may be supported by the air and carried long distances suspended in it in a living state. The breath of the sick person, is, there is reason to think, in many cases loaded with contagious germs ; and there is little doubt that the cutaneous exhalation contains them. It is, therefore, of the utmost importance that means should be taken to destroy these particles before they can leave the neighbourhood of the sick person or the sick room. At the same time it is certain that of healthy persons exposed to the influence of these germs, by far the great majority will escape infection. And observation and experience justify the conclusion that nurses and attendants really run little risk of contracting contagious fevers from the patient, unless they are themselves out of health. A healthy nurse who takes the ordinary precautions for keeping herself in good health, may be continually exposed to contagion, and

devote her life to the service of the sick, without once being attacked. But this is no reason for relaxing in the slightest degree our efforts to extinguish contagious poisons, and the greatest precautions should, in all cases, be taken to destroy all contagious disease germs as soon as possible after they have come into existence. For this purpose some easily obtainable volatile vapour must be employed.

Chlorine and sulphurous acid are very efficient, but neither the patient nor the attendants can long support an atmosphere containing a high percentage of either of these deleterious gases; and even when mere traces are present the atmosphere is extremely unpleasant. Moreover, as they are positively injurious to the respiratory organs, both of the healthy and sick, their employment in the sick room requires the greatest care. The vapour which is given off from chloride of lime or chlorinated lime, although perfectly harmless is excessively disagreeable, and the associations inseparable from this odour are so unpleasant that some substitute for it is unquestionably most desirable.

Sulphurous acid gas is a most powerful disinfectant, and acts beneficially in checking the spread of contagious diseases by destroying the living germs. It has been proved, experimentally, that a very weak solution stops the growth and multiplication of the yeast fungus and penicillium glaucum, and destroys the lower forms of life.

The purifying effects of the products of burning sulphur were known to the ancients, and this substance has been used ever since for the purpose of removing the smell of decomposing animal substances.*

Sulphurous acid destroys the odour of many offensive gases. "It attacks sulphuretted hydrogen, entirely destroying it; it neutralizes the strong smell of ammonia and other alkaline bases, converting them into sulphites, but without destroying their manurial value, or losing its antiseptic properties." (Crookes).

In order to generate sulphurous acid for the purpose of purifying a room after it has been occupied by the sick, or which has been used as a mortuary, two or three lumps of common brimstone may be placed in a garden saucer, iron pan, or other flat vessel, resting on some bricks, and lighted with a red hot iron. The windows and doors of the room being closed, the sulphur may be left to burn itself out. After the lapse of five or six hours the room is purified, and air may be re-admitted.

Sulphites have been largely employed in medicine,

* "Bring purifying sulphur, dame, bring fire,
To fumigate the house - - - -
Nurse Euryclea disobeyed him not;
But brought both fire and sulphur; and he then
Did fumigate the chamber all throughout."

The Odyssey of Homer, translated by G. W. Edgington, Licentiate in Medicine, Book XXII., Vol. II. pp. 159, 160.

both externally and internally. Professor Polli has performed a vast number of experiments, and he is quite satisfied of the efficacy of this class of salts. Many other Italian Physicians have also borne testimony to the value of the sulphites.

An aqueous solution of sulphurous acid is now included in the British Pharmacopœia. It may be given internally in doses of half a fluid drachm further diluted with water, or may be used as an application to various surfaces. Sulphite and hyposulphite of soda have both been recommended for the purpose of destroying the lower vegetable organisms, and appear to have been efficacious in some cases of sarcina. The dose of each salt is from 10 to 60 grains dissolved in water. I have myself employed these remedies in severe cases of *sarcina ventriculi*, but have been disappointed in the result in several instances. Probably the great number of the vegetable fungi present, and the circumstance of their being embedded in viscid mucus, rendered their destruction by such means impossible. The viscid mucus in which they are embedded, and in which they grow and multiply, securely protects them from the action of the remedy, and prevents the latter from coming into contact with them.

Other disinfecting Volatile Vapours—Pitch and Tar.—There are certain vapours obtained in the destructive distillation of wood and coal, which, there is good reason to believe, are really efficient in destroy-

ing the life of contagious disease germs, as well as offensive smells. The smoke from the burning of pitch and tar has long been celebrated for its purifying properties. Even the vapour of tar is held to be serviceable in this way. A minute trace of some of the ingredients of tar dissolved in water is certainly destructive to many of the lower forms of life. Pitch and tar have been used as disinfectants from the earliest times. The material used by the ancient Egyptians for embalming, was obtained from pitch. The active antiseptic agents, it has recently been shown, are carbolic and cresylic acids, which are now extracted in large quantities and used in a pure state. Of these, the first is the most important. The antiseptic properties of wood smoke and of creosote, are due mainly to the carbolic acid which is present.

Carbolic Acid.—During the prevalence of the Cattle Plague, many experiments were tried with these substances, but of all that were employed, carbolic acid was, there is reason to think, the most efficacious. This substance, which was obtained by Laurent under the name of phenic acid from the oil of coal tar, has of late years been made in large quantities by Messrs. Calvert & Co., of Manchester.

Carbolic Acid is highly volatile, and diffuses itself with remarkable rapidity. The vapour is not in any way injurious to linen, metals, or furniture. It is perfectly harmless, and so far from being disagreeable, the odour is one to which we readily become accustomed,

and its effect upon the olfactory nerves of some persons is almost pleasant. To the efficacy of carbolic acid, numerous facts advanced in the following pages, abundantly testify. For much of what is known concerning the action of carbolic acid, we are indebted to Mr. Crookes, who has performed a great number of most careful experiments, by which it appears to me the usefulness of this disinfectant is established. In order that the reader may form a general notion of the nature of the evidence upon which this conclusion is based, I propose to give a short account of Mr. Crookes' researches, and the results he has arrived at.

In his report to Her Majesty's Commissioners, in 1866, Mr. Crookes has drawn conclusions concerning the nature of the poison of cattle plague, almost identical with my own detailed in this work. This agreement is remarkable, inasmuch as two very different methods of investigation have been pursued by us, and quite independently. The two reports were presented at the same time, and neither observer was aware of the results arrived at by the other. In this case chemical investigation and microscopic observation have led to the adoption of similar inferences, and the establishment of the same kind of theory concerning the nature and action of contagious poisons.

Mr. Crookes' Observations on Disinfectants.

Disinfectants of value in Cattle Plague.—The infectious matter, it appears to have been satisfactorily proved, passes off mainly from the lungs of diseased animals, and attacks healthy ones through the same channel. The particles of contagion being so extremely minute, are suspended in the atmosphere, and partake in this manner of the physical properties of very fine dust. It would be clearly hopeless, says Mr. Crookes, to attempt to combat the virus by non-volatile, solid, or liquid disinfectants. The desideratum being a "volatile and liquid disinfectant which will, after first acting on the excreta, the floors, walls, &c., by its gaseous diffusion, rise into the air, enter the lungs of the animals, pervade the whole building, and attack the hidden germs of infection, which otherwise would escape"—all this being done with the least possible inconvenience to the cattle and their keepers.

Eschewing hydrochloric acid gas, which is irritating to the respiratory organs and inferior in action to other agents, and also oil of tar and petroleum, whose value depends merely on the small amount of tar acid they contain, Mr. Crookes limited himself to the oxidizing disinfectants—chlorine and ozone, and the antiseptics—sulphurous and the tar acids.

And first with reference to the action of powerful oxidizing disinfectants like chlorine or ozone, than

which Mr. Crookes observes, nothing appears more perfect upon noxious vapours and septic germs, "Could we always rely upon the presence of a sufficient amount of either of these bodies no other purifier would be needed." The utter impossibility, however, of obtaining an adequate and continual supply over an area of any extent is obvious. The great objection to the use of disinfectants which act by oxidation, Mr. C. finds in the fact, that the fœtid odours and gases in a given area, which are, as regards cattle plague, perfectly harmless, are the first to be overcome, while the actual virus of the disease, the particles of bioplasm which are altogether inodorous in themselves, are the last to be attacked by these vapours. Mere deodorization, therefore, is of no effect, and affords no protection whatever.

Of Carbolic and Cresylic Acids.—Carbolic and cresylic acids have great similarity in odour and other properties, though distinct bodies. A white crystalline, solid, pure, carbolic acid, melts at 34° C. and is distilled at 180° C. Cresylic acid is a liquid, and boils at 203°. In the opinion of Dr. Angus Smith, who conclusively proved that the putrefactive decompositions in soils which produce malaria do not occur in the presence of very minute quantities of carbolic acid, the antiseptic properties of cresylic acid rival, if if they do not surpass, those of carbolic acid.

The great value of carbolic acid as an antiseptic, is said by some to be due simply to its affinity for

oxygen, it being supposed that it acts merely by preventing oxidation. In order to a thorough clearing up of this point, Mr. Crookes made the following experiment :—

Metallic sodium was cut into lumps with a sharp knife : the change of colour of the surfaces indicating very plainly the progress of the oxidation. The same was done several times in an atmosphere strongly charged with the vapour of carbolic acid, while comparative experiments were made at the same time in pure air. Result—no difference in the rate or amount of oxidation. In a *second experiment*, "a colourless solution of subchloride of copper in ammonia was divided into two parts, and one part mixed with a little carbolic acid. On pouring the two portions through the air into flat dishes, no difference whatever on the progress of the oxidation could be detected." *In another*, "a mixture of pyrogallic acid and a solution of potash was shaken up in a large stoppered bottle. It was then opened under water, and the amount of oxygen noted. The same experiment was repeated after the addition of carbolic acid. On opening the bottles under water, the absorption was found to be the same as before." *In a fourth experiment*, a "'philosophical lamp' was made by arranging a platinum spiral over the wick of a spirit lamp, containing alcohol mixed with a little ether. On lighting, and then blowing it out, the platinum continued to glow brightly. Pieces of solid carbolic

acid were then carefully placed in the cup of the brass wick. The heat soon melted the acid and raised its vapour round the platinum spiral, but without occasioning any alteration in the brightness of its glow."

These experiments, with others not quoted here, we think with Mr. Crookes, prove conclusively that the tar acids have no special power of preventing oxidation.

Deodorizers and Disinfectants.—In the following important experiments, Mr. Crookes points out in a striking manner the difference between a mere deodorizer and an antiseptic, like carbolic acid :—

"Some meat was hung up till the odour of putrefaction was strong; it was then divided into two pieces ; one was soaked for half-an-hour in chloride of lime solution, and was then washed and hung up again ; the offensive smell had entirely gone. The other piece of meat was soaked in a solution of carbolic acid containing one per cent. of the acid ; it was then dried and hung up. The surface of the meat was whitened, its offensive odour was not removed, though it was masked by that of the carbolic acid. In two days the bad odour had quite gone, and was replaced by a pure but faint smell of carbolic acid. In a few weeks' time, the pieces of meat were examined again. The piece which had been deodorized with chloride of lime now smelt as offensively as it did at first, whilst the piece treated with carbolic acid had simply dried up, and had no offensive odour whatever. It was then

hung up for another month. No change had taken place when examined at the end of that time.

As a companion experiment to the above, "a piece of fresh meat was soaked in a 1 per cent. solution of carbolic acid for one hour, it was then wrapped in paper and hung up in a sitting-room in which there was a fire almost daily; at the end of ten weeks it was examined; it had dried up to about one-fourth of its original size, but looked and smelt perfectly fresh, having but a very faint odour of carbolic acid. It was soaked for twenty-four hours in water, and stewed with appropriate condiments, and then eaten; it was perfectly sweet, and scarcely distinguishable from fresh meat, except by possessing a very faint flavour of carbolic acid, not strong enough to be unpleasant."

In the first of these experiments it was plain that the chloride of lime, one of the most potent of deodorizers, acted merely on the gases of the existing putrefaction, while the carbolic acid, exerting scarcely any influence on the fœtid gases, "attacked the cause which produced them, and at the same time put the organic matter in such a state, that it never re-acquired its tendency to putrefy."

How Carbolic Acid acts in arresting decomposition.—With the view of ascertaining in what way carbolic acid acted in arresting decomposition, Mr. Crookes next made the following experiment: "Albumen was mixed with four times its bulk of water, and a one per

cent. solution of pure carbolic acid was added to it. No change took place for the first few minutes, but after a little time, a white cloudiness was formed which gradually collected together into a coagulum. On separating this and exposing it freely to the air, it entirely resisted putrefactive decomposition. The solution strained from the coagulum still contained carbolic acid and uncoagulated albumen."

In an exactly similar experiment, in which cresylic acid was substituted for carbolic acid, the mixed solutions remained clear for half-an-hour, showing that this body has a still slighter affinity for albumen, and rendering it evident that the tar acids do not owe their special action to their coagulating properties on albumen.

The exertion by carbolic acid of a special action on germination and upon the living matter of fungi, Mr. Crookes thinks is proved conclusively by the fact that it not only arrests fermentation instantly when in progress, but prevents all future fermentation, as shown in the subjoined instances. "A few drops of carbolic acid added to half a pint of sugar syrup and yeast in full action immediately put a stop to the fermentation." "Fresh brewer's yeast was first washed with a solution of one per cent. of carbolic acid and then with water. Its power of inducing fermentation in a solution of sugar was entirely destroyed, although no perceptible change in the appearance of the yeast cells under the microscope could be detected. Repeated

several times, this experiment always gave the same result, but when the yeast was merely washed with water, it readily induced fermentation."

In order to determine whether the tar acids were influenced in the same manner as certain well known chemical bodies which are supposed to act by fermentation, "a solution of diastase (infusion of malt,) was mixed with thick starch paste and one per cent. solution of carbolic acid. On gently heating for a short time, the starch was converted into dextrine as completely as if no carbolic acid had been present."

"Amygdalin was mixed with synaptase (emulsion of sweet almonds) in the presence of carbolic acid; the formation of the essential oil took place with apparently the same readiness as if carbolic acid had been absent." These results show that carbolic acid exerts no influence whatever on purely chemical ferments, which, as in the case of those above employed, consist of definite nitrogenous compounds, and act simply by chemical affinity, and cannot therefore come into the same category with true ferments, which are living bodies—bioplasts. They also go far to prove that carbolic acid attacks the vitality of the bioplasmic matter of the ferment in some peculiar way, exerting no interfering action where an effect is due merely to the so-called catalytic action. Moreover, tested in other ways, it was rendered probable that carbolic acid acted directly upon the living growing matter.

Action of Carbolic Acid on other living organisms.—

Cheese mites immersed in water, lived for several hours. A drop or two of solution of carbolic acid containing one per cent. added to the water killed them instantly. A few drops of the solution added to the same water in which a small fish was swimming, killed it in a few minutes. To water containing various infusoria—bacteria, vibriones, spirilla, amœbæ, monads, euglenæa, paramecia, rotifera, and vorticellæ, a very minute quantity of the solution added, proved fatal instantly, arresting at once the movements of all the animalcules.

Carbolic acid injected into blood vessels of a living animal in health kills it, the circulation instantly being arrested, though the blood is not coagulated. The living matter of the flowing blood being killed, seems to be the sole cause of the stoppage of the circulation.

Carbolic Acid a Test of Vital Phenomena.—The powerful action which carbolic acid exerts on vital phenomena, renders it, in Mr. Crookes' opinion, the "test proper for distinguishing vital from purely physical phenomena," possessing, as it undoubtedly does, an action characterised in almost all cases by the certainty and definiteness of a chemical reagent. In its presence embryonic life is impossible; under its powerful influence all minute forms of life perish. Experimentalists in France have over and over again tested its destructive power upon the living particles of vaccine lymph. If thoroughly mixed with a mere

trace of carbolic acid the lymph is always rendered entirely innocuous, while the employment of the unadulterated lymph is followed by the usual results.

Action of Carbolic Acid on the Virus of Cattle Plague.—The virus of cattle plague, as would seem by the ensuing experiment, is equally amenable to the influence of carbolic acid. The air from a cowshed in which were several animals in the last stage of cattle plague, was passed through two glass tubes in which was cotton wool, in the hope that some of the disease germs supposed to be thickly floating in the air, might become entangled in the wool. One piece of the wool thus infected was exposed to the vapour of carbolic acid for half an hour. Then, selecting two apparently healthy calves, an incision was made beneath the skin of each, and one of the pieces of wool inserted. The animal into which the infected wool which had been exposed to the carbolic acid vapour had been introduced, remained perfectly well, but the other animal took cattle plague, and died of it in a few days.

Disinfecting Cow Sheds by Carbolic Acid.—Several interesting particulars and valuable facts are given by Mr. Crookes in his experiments on disinfecting cattle at the various farm buildings he visited, with reference to the *modus operandi* and action of carbolic acid in disinfecting places like cow sheds, &c. For instance, an isolated shed wherein no system of disinfecting had been adopted, in which several animals

had died—being, in fact, then used as a hospital for the cattle as they fell sick, one of which, almost moribund, it contained when Mr. Crookes asked and obtained permission to try certain experiments in the way of disinfecting the place. The stench was very bad. The sick animal was first removed outside, the litter cleared away, and the floor washed with a two per cent. solution of carbolic acid. The walls, roof, rafters, &c., were whitewashed with lime water, plentifully mixed with carbolic acid. The doors and all ventilating holes were then stopped up with hay, and a pound of sulphur was burnt in the middle of the floor. After the vapour of the sulphur was all cleared away, the diseased beast formerly occupying the shed was tied up at one end and a healthy animal was fastened near the door. The size of the shed being only 15 ft. by 9 ft., was insufficient to prevent the animals touching occasionally. Directions were given to continue treating the sick animal as hitherto, and give the healthy one an ounce of carbolic acid a-day mixed with his food. The shed daily to be sprinkled with carbolic acid all over the floor and walls, and whitewashed as before every fortnight. In a few days, from the closeness of the quarters, actual inoculation of the healthy animal with the disease might be said to have occurred, for the hind quarters of the healthy beast being soiled with the alvine discharges from the diseased one, on one occasion, the former was seen to lick the part so smeared.

Absolute immunity was hardly to be expected now therefore.

Put together on the 15th of February, the diseased one died on the 21st, and was replaced by another diseased animal; but it was not until a month had elapsed that the healthy animal showed any symptoms of illness, and then only in a very mild form, recovering in a few days. Now, allowing nine days for the period of incubation, this experiment clearly shows that by the free use of carbolic and sulphurous acids absolute immunity from contagion was ensured, and that when the animal under so severe a test did succumb, the disease was deprived of its malignant character.

A case is recorded by Mr. Crookes, in which the cattle plague was communicated to a herd of cows by the carelessness of a cowman, who, having attended a post mortem examination of some beasts dead of cattle plague on a neighbouring farm, went directly afterwards to Mr. Lowe's houses and milked some of the cows. Every one of the cows the man touched died. The liberal use of carbolic acid prevented the others from falling victims.

Crucial Experiment of the Value of Carbolic Acid.—A crucial experiment of immense value supplied by accident, but none the less satisfactory and decisive, was tried by Mr. Crookes on a grand scale, on a farm, the very hot bed of cattle plague. The cattle were divided into two lots, 45 in disinfected houses,

28 in undisinfected open sheds. The disease was communicated to each lot by direct inoculation of the virus. Only those actually inoculated, of the disinfected animals fall a prey; while of those not protected by disinfection, the whole are quickly destroyed; and, as if to make indubitable proof doubly certain, and fix the eye of credit on the true cause of such results, a few weeks later, the remainder of those 45 disinfected animals, being unwisely turned out to grass, and removed from the protecting influence of the carbolic acid, the plague attacked and killed the whole of them within a few days.

Having drawn attention to these facts, which distinctly indicate the general nature of the material constituting the virus or contagion of contagious diseases and the changes wrought by a powerful volatile substance like carbolic acid, we may with propriety proceed to consider more in detail the question of destroying contagious bioplasm. In the first place it is necessary to draw attention to the fact, that living pus corpuscles may be destroyed, and their rapid growth and multiplication retarded by subjecting them to the influence of certain reagents (p. 290).

On Destroying Living Bioplasm and Checking Its Growth.

On the Free Growth of Morbid Bioplasm in Inflammation.—The soft rapidly growing matter, which forms in vast quantity upon many an ulcer, retards the heal-

ing process. The surgeon has discovered by experiment, that, if he would promote a return to the healthy state, he must endeavour to check the redundant growth of this soft pulpy matter. Such a result may be effected in many ways. Sometimes exposure to air is sufficient to check the free growth of the soft pultaceous matter, and cause its anatomical elements to dry and harden, so as to form a "scab," beneath which a more lasting cuticular layer may be afterwards slowly developed. If this should not, however, be the case, more potent means are resorted to. Solutions, which have the property of coagulating albumen are applied, or a stick of nitrate of silver is smeared over the raw surface, or the latter is touched with a crystal of sulphate of copper. The soft pulpy rapidly growing structure consists of multitudes of bioplasts, many of which are instantly destroyed by the reagents above referred to, while the free growth of those just below the surface is retarded by the action of the more diluted solution of the salt which reaches them. The growing process thus directly checked by our interference might be again promoted by protecting the surface from the air and keeping it warm and moist. When the surgeon applies caustics and "stimulating" lotions of zinc, nitrate of silver, alcohol, &c., he really checks redundant growth,—instead of "exciting" increased and healthy action as is usually asserted, action already excessive and exhausting, and worse than useless, is reduced. The

more healthy state of the wound is due to the slower rate at which changes take place upon its surface. Camphor and a number of other substances act in the same way, and it is probable that carbolic acid exerts a similar influence. In the treatment of pus formation proceeding upon the surface of mucous membranes, many substances which have the property of coagulating albumen have been found eminently useful, and are continually employed in practice. Most of the astringent injections which experience has shown to be of service, when injected into mucous canals, the lining of which is in a morbid state from the increased activity of the bioplasm, undoubtedly act by destroying many of the rapidly growing bioplasts or pus corpuscles, especially the youngest and most minute. Benefit also results from the indirect action of the remedy in effecting upon and beneath the mucous membrane changes which are less favourable to the formation and nutrition of the pus bioplasts.

The destruction of the bioplasm in the blood and in internal parts of the body in cases of fever, will be more conveniently considered after the antiseptic treatment of wounds has been discussed. (*See* pp. 300, 305).

The Antiseptic Treatment of Wounds.

Pitch and tar were used in the treatment of wounds a century and more ago. The benefit resulting from their use, was probably due to the presence of sub-

stances which have since been separated, and are now employed in a purer form.

The value of coal tar in restraining suppuration has been long known. Démeaux, and afterwards Lemaire, employed this substance as early as 1859. Dr. Wolfe, of Aberdeen, who used carbolic acid in the treatment of wounds in 1864, advanced the opinion that it interfered directly with the pus forming process. Lemaire entertained a similar view, but of late a very different explanation of the action of carbolic acid has been given by Professor Lister, and widely taught. Lister's views have been very generally received, and his practice has been adopted by many distinguished surgeons in this country and abroad. Before Lister advocated the use of carbolic acid in the treatment of wounds, various other substances had been employed. For many years past Mr. De Morgan has used chloride of zinc in the proportion of forty grains to the ounce of water. The surface of the wound being repeatedly washed, a firm coagulum is formed, which resists putrefactive change. Beneath this the healing process usually proceeds without the occurrence of suppuration. Perchloride of iron is another very valuable antiseptic application. Equal parts of the tinct. ferri perchlor. and glycerine is one of the most useful preparations for the treatment of superficial ulcers about the mouth, throat, and parts about the fauces. Tincture of iron has been much used in the treatment of wounds by the late Mr. Nunneley, of Leeds (*Brit. Med. Journ.*,

Aug. 7th, 1869). Solutions of sulphate of zinc, bichloride of mercury, acetate of lead, sulphate of copper, and other metallic salts, have been used almost from ancient times in the treatment of wounds.

Carbolic Acid, although very slightly soluble in water, is readily dissolved in glycerine. *Glycerinum acidi carbolici* is a preparation in the British Pharmacopœia. It consists of one ounce of the acid and four ounces of glycerine, which are to be rubbed together until the acid is dissolved.

Mr. Lister is careful to prevent the ingress of non-carbolised air into any wound which has not been subjected to the influence of carbolic acid. In like manner the instruments used are moistened with a solution of the same reagent. In abscesses the opening is carefully guarded by some preparation of carbolic acid, and every precaution is taken during the dressing to prevent the entrance of air which has not been rendered antiseptic by admixture with carbolic acid vapour.

The composition of many of the medicaments recommended by Mr. Lister is subjoined. *Carbolised Oil.*—Crystallised carbolic acid, 1 part. Boiled linseed oil, 4 parts: dissolve. *Carbolised Putty.*—Carbolised oil, about 6 tablespoonfuls. Common whitening (chalk), sufficient to make a firm paste.

Antiseptic Lead Plaster.—Olive oil, 12 parts (by measure); litharge (finely ground), 12 parts (by weight); beeswax, 3 parts (by weight); crystallised carbolic

acid, $2\frac{1}{2}$ parts (by weight). Heat half the olive oil over a slow fire, then add the litharge gradually, stirring constantly till the mass becomes thick or a little stiff; then add the other half of the oil, stirring as before till it becomes again thick. Then add the wax gradually till the liquid again thickens. Remove from the fire, and add the acid, stirring briskly till thoroughly mixed. Cover up close, and set aside to allow all the residual litharge to settle; then pour off the fluid, and spread upon calico to the proper thickness. The plaster made in this way can be spread by machine and kept rolled in stock; and, if in a well-fitting tin canister, will retain its virtues for any length of time.

Antiseptic Lac-Plaster.—Shellac, 3 parts; crystallised carbolic acid, 1 part. Heat the lac, with about one-third of the carbolic acid, over a slow fire till completely melted; then remove from the fire and add the remainder of the acid, and stir briskly till the ingredients are thoroughly mixed; strain through muslin and pour into the machine for spreading plaster; and, when the liquid is thickened by cooling to a degree ascertained by experience, spread to the thickness of about one-fiftieth of an inch. Afterwards brush over the surface of the plaster lightly with a solution of gutta percha in about 30 parts of bisulphide of carbon. When the sulphide has all evaporated, the plaster may be piled in suitable lengths in a tin box without adhering, or rolled up in a canister.

Antiseptic Muslin Gauze.—Paraffin, 16 parts; resin, 4 parts; crystallised carbolic acid, 1 part. Melt together. Cheap muslin gauze is dipped into the mass and well wrung or pressed while hot. This is a good substitute for oakum as an antiseptic covering for wounds, unirritating to the most sensitive skin, highly retentive of the acid, and almost destitute of odour. It should, when used, be folded in about eight layers. It loses the paraffin and resin when washed in boiling water, so the same gauze may be used repeatedly.

Protective against local irritating effects of carbolic acid in antiseptic dressings. Varnish oil silk on both surfaces with copal varnish. When dry, brush over with a mixture of starch and dextrine to give it a film of material soluble in water, so that it becomes uniformly moistened when dipped into antiseptic lotion. When not at hand, common oil silk may be used as a substitute for it if smeared with an oily solution of carbolic acid, and used in two layers to make up for its inferior efficacy.

Antiseptic Catgut Ligature.—Catgut of the thicknesses required is to be kept steeped in carbolised olive oil (1 part in 5) with a very small quantity of water diffused throughout it. The small proportion of water present renders the gut supple, and so changes it, that it may be transferred to a watery solution at the commencement of an operation, and thus kept supple without swelling or perceptibly changing in strength or bulk.

The following is a list of the most important of Professor Lister's recent communications:—

Case of Compound Fracture Treated Antiseptically.—*Lancet*, March 16, 1867, p. 328.

Observations on Ligatures of Arteries on the Antiseptic System.—*Lancet*, April 3, 1869. Corrected Feb. 1870.—Churchill.

Introductory Lecture.—Edinburgh, Nov., 1869.—Edmonston and Douglas, Edin.

On the Effects of the Antiseptic System of Treatment upon the Salubrity of a Surgical Hospital, 1870. Edmonston and Douglas.—Edin.

Remarks on a Case of Compound Dislocation of the Ankle. Illustrating the Antiseptic System of Treatment, 1870.—Edmonston and Douglas.—Edin.

Although there is no doubt of the advantage of the *practice* advocated by Mr. Lister, the *theory* advanced by him to explain the results is defective, and has already been much criticised. There is reason to fear that the unsatisfactory theory has influenced some minds against the excellent practice. It is, therefore, desirable to show that the defects of the former in no way whatever prejudice the facts which establish the value of the latter. Professor Lister attributes certain pathological phenomena to the operation of stimuli, and to the influence of irritation, but he does not tell us in what particular manner the so-called stimuli act, nor does he describe the changes which he conceives

to take place during the operation of the irritation. Such phrases must be fully explained before they can be accepted as explanations of the phenomena to which they refer. Pus, it is said, results from "abnormal stimulation of the tissues;" but the meaning of the term stimulation is not defined, and we are left as much in the dark as by our many predecessors who were contented to attribute all morbid phenomena to the operation of mysterious and inexplicable agents and forces. Lister further remarks, that no stimulus can alone induce healthy tissues to suppurate, but that when they have been "gradually degraded" under the influence of "protracted abnormal stimulation into the *most imperfect* of all tissues, which, when we see it at the surface of a sore we term granulations, (!) that they are in a condition if further stimulated to give birth to the still lower progeny of pus-corpuscles."* Here is a whole string of hypotheses, not one of which has been or can be substantiated. Such a pathology appears to me wholly retrograde and indefensible. Pus formation is attributed to irritation, and the irritation generally at any rate, is supposed to result from the presence of decomposing organic matter.

Professor Lister endeavours to show how his theory is borne out by experience. He remarks: "My experience leads me to believe that if, when the dress-

* "Remarks on a Case of a Compound Dislocation of the Ankle," p. 26. 1870.

ings are removed, a single drop of serum were to be pressed out by the movement of the limb and then regurgitate into the interior, *after being exposed for a second to the influence of septic air*, putrefaction would be pretty certain to occur." Further, he lays it down that the putrefaction is caused by the presence of bacteria, and suggests that these may be carried from the air into deep parts upon an unprotected knife or upon a probe or canula. By the antiseptic treatment, however, the bacteria are destroyed, and thus the subsequent decomposition of the organic matters prevented. The irritation of which pus-formation is a consequence is thus completely averted, and the healing process without pus-formation ensured. The "antiseptic system of treatment consists of such management of a surgical case as shall effectually prevent the occurrence of putrefaction in the part concerned."*

There is no doubt whatever that carbolic acid vapour does prevent putrefaction, and it is very probable that its influence depends upon the destruction of bacteria, and the establishment of conditions which render it impossible for these low organisms to multiply.

Dr. Crace Calvert (*Chem. News*, Dec. 9th, 1870) found in a series of experiments that meat became tainted when suspended in the air in bottles at the bottom of which had been placed known quantities of permanganate of potash, chloralum, McDougall's

* Introductory Lecture. Edinburgh, Nov. 8, 1860.

powder, chloride of lime, tar oil, and chloride of zinc, in periods varying from two to nineteen days; while pieces of meat exposed in the same way in bottles containing carbolic acid powder, carbolic acid, and cresylic acid only dried up without becoming tainted at all. These observations have been confirmed by many other experimenters.

But, in order to accept Lister's theory, we must consider it proved not only that bacteria are the cause of putrefaction, but that pus-formation depends upon irritation, and that putrefactive change exerts the particular irritation which is prone to excite the development of pus. Whereas it seems more reasonable to conclude that the carbolic acid which kills the bacteria also destroys the life of the pus corpuscle.

The occurrence of putrefaction is considered by Lister to be the starting point of pyæmia and some other morbid phenomena, but it has surely escaped the notice of the advocate of this hypothesis that, on the one hand, we may have the putrefactive change without pyæmia being occasioned, and on the other, the latter condition brought about independently of putrefaction; just as we may imbibe the most disastrous fever poisons without being annoyed with the least unpleasant smell, and experience the most disgusting odours without suffering in the least degree from any septic poison.

But it has not been proved that pus-formation is invariably accompanied and preceded by the develop-

ment of bacteria, and it seems much more reasonable to attribute the beneficial influence of carbolic acid to its direct influence upon the living growing pus corpuscles, than it would be to accept the roundabout explanation which has here been submitted to examination.

The living matter of pus (see page 275), we may prove experimentally is killed by a weak solution of carbolic acid, and this substance very much diluted would tend to interfere with its rapid growth by causing hardening of the outer part of the corpuscle and the formation of a cell wall.* Such an agent as carbolic acid effectually stops those changes of form which occur when pus corpuscles are multiplying (see page 128). That bacteria are often found in pus as well as in other animal products is quite true, but it is not probable that their presence is in any way connected with the process of suppuration. For if this were so, we ought to find bacteria in cases in which none are to be detected, and these bodies ought not to be present under circumstances in which great numbers are to be actually seen. As is well known, multitudes of bacteria are always to be detected upon the dorsum of the tongue and in the fluids of the mouth, but these parts are not more prone to suppuration than others. That morbid processes commonly affect the tongue and mouth is well known, but the presence of millions

* Dr. Sansom adduces a case of extremely severe purulent bronchitis which was rapidly benefited by carbolic acid inhalation. "The Antiseptic System," p. 292.

of bacteria does not seem to influence the phenomena in any way. Wounds in the mouth, as is well known, heal very quickly, notwithstanding the irritation which ought, according to the theory, to be produced by the putrefactive decompositions which undoubtedly occur, and which are probably occasioned by the multitudes of bacteria which are always growing in and upon the epithelium. These bacteria are always being swallowed and, probably, in the healthy state, are destroyed by the digestive process, and the product resulting from their destruction afterwards absorbed. It seems, therefore, very doubtful if Prof. Lister's excellent results in the treatment of wounds and operations can be due to the destruction of the bacteria by the carbolic acid and the prevention of the entrance of a few germs from the air into a recent wound. Is it not more probable that the extreme care taken by him in order to ensure the above object is useful in some other way? Has it been proved that if the same care be taken as regards the management of the wound and the dressing, a similar favourable result will not be obtained even if the access of bacteria is permitted?

It has been assumed in cases in which bacteria have been detected in the pus that these, or the germs from which they were developed, must have found their way direct from the air, but it seems to me that the evidence adduced in favour of this view is not conclusive, while other facts and considerations render it much

more probable that the germs were derived from some which existed in a passive dormant state in the tissue itself (*see* page 66). Such an origin appears never to have suggested itself to Prof. Lister, and he remarks, as if it were an argument in favour of his doctrine, that if we do not admit that the germs were introduced from without, there is nothing left for us but to accept the ridiculous notion that bacteria were formed spontaneously out of the pus. Bacteria can no more be produced by pus than they can by epithelium. Pus can have no more to do with the origin of bacteria than the latter with the origin of pus. Pus may live without bacteria and bacteria without pus. If we assume that the only way in which bacteria can get into the substance of the tissues is directly from the outer air, we shall find it impossible to explain some of the facts adverted to on p. 69, and new difficulties would arise in connection with other phenomena, which are to be fully accounted for if, as I believe is the fact, living bacteria germs exist dormant in the tissues even in the healthy state, but do not grow and multiply unless certain changes take place in the organic matters around them.

And it seems equally unreasonable to infer that when bacteria are found in the blood, the germs obtained access to that fluid from without shortly before they were discovered. Bacteria are developed upon the surfaces of calculi in the urinary organs, and probably exist in some parts of the living fœtus while yet in

utero. And it is surely more probable that the bacteria germs were carried to the fœtus by the maternal blood and passed through the delicate membranes which separate this from the blood of the fœtus, than that they found their way direct to the inner parts of the embryo from the outer air. The former supposition is quite in accordance with what we know concerning the passage of disease germs from the maternal to the fœtal blood in certain cases; the latter is unsupported by evidence of any kind.

Indirectly, of course, all bacteria germs are derived from without, but not just prior to their appearance in great multitudes in internal parts of the body, as has been surmised. Bacteria germs less than the $\frac{1}{100000}$th of an inch in diameter can readily gain access to all parts of the organism, and probably remain alive, though quiescent, for a long while. They may be destroyed in vast numbers in the healthy state of the body, though, under certain local changes, the conditions become favourable to their development and multiplication. It has not been proved that these bacteria or their germs, "microzymes," have anything to do either with the condition of health or disease, and it has been shown that they do not necessarily give rise to suppuration, inflammation, or other morbid change. Nor has any form of fungus germ whatever been proved to produce any contagious fever. The fungous germ theory of disease, as already shown in pp. 78, 236, cannot be sustained unless many

important facts are altogether ignored. Nor is it more probable, that the so-called microzymes, which ultimately become bacteria and vibriones, but never, according to Dr. Sanderson, result in developing fungi, have anything whatever to do with the production or propagation of contagion. It must be clearly understood that the minute particles of bioplasm, described and figured by me in 1863, and in the second part of this work, are certainly not of the nature of microzymes or fungi of any kind whatever ; they cannot be called microzymes unless the meaning of the word be completely changed. A microzyme becomes a bacterium. A disease germ has no connection with bacteria, microzymes or fungi, either as regards its nature, properties, or origin. The particles figured by me in 1864 in vaccine lymph do not resemble the so-called "microzymes" figured subsequently, and said to exist in that fluid *. Some of Dr. Sanderson's illustrations, described as active particles of vaccine, are, indeed, sketches of bacteria or fungus germs, which have grown in the virus after its removal from the vesicle, and which may be regarded as accidental, and of no importance whatever. So far from being the active agents of vaccine or other virus, they simply indicate that the fluid is undergoing post mortem change, and is losing, if it has not already lost, its remarkable disease producing properties.

* Twelfth Report, &c. Page 232. Fig. 1.

Of Destroying Disease Germs before and after they have entered, and after they have left, the Body.

Destruction of Disease Germs after their escape from the Body in Sewage, &c.—During many years past, attention has been drawn to this part of the subject by all who see the necessity—and who does not ?—of sanitary reform. Its importance has been fully recognised by the public, and our most distinguished statesmen are evidently determined that measures shall be introduced for the purpose of mitigating the terrible evils resulting from the preservation of disease germs in the genial soil of the sewage, and their introduction into our houses, and even into our bed-rooms, and last but not least in importance, for preventing their escape from the sewage into our drinking water, whereby their introduction into our organism is insured.

Probably the only efficient way of destroying the germs escaping from the sick person in his excretions is to mix with them disinfectants before they leave the sick room to be washed into the drains. And, practically, the only thoroughly efficient mode of disinfecting the sewage is by adding the disinfectant in each house, and so effecting the change in the matter before it becomes sewage. *Sulphate of iron*, *chloride of lime*, *Burnett's fluid*, *Condy's fluid*, or *carbolic acid*, may be used for this purpose. Every practitioner should insist upon the importance of this proceeding, and the nurse

should be instructed never to omit the use of disinfectants in contagious diseases.

Many materials have been recommended for the purpose of disinfecting the secretions, linen, &c., of the sick, and although there will always be difficulty in deciding which is really the most effective, it is probable that all those in common use are efficient.

The Chloride of Lime.—Chlorinated lime or hypochlorite of lime is well known, as it is in common use. It is no doubt really efficient, but its smell is very unpleasant, and to some persons excessively disagreeable.

Solution of Chloride of Zinc—under the name of Burnett's fluid—is also in ordinary use. It is very valuable as a disinfectant and antiseptic, but it is highly corrosive and very poisonous.

Copperas, or Green Vitriol.—In order to disinfect the secretions before they leave the sick room, a solution of common copperas or green vitriol may be used. This is one of the cheapest and most valuable of disinfectants. From one to two pounds of copperas to a gallon of water will make the disinfecting solution, of which half a pint may be poured into the night stool or bed pan.

Calvert's Carbolic Powder is a very convenient disinfectant. It may be placed in saucers about the room, or in little bags in the patient's bed, or with linen and clothes. It may also be mixed with the excretions, just as chloride of lime, copperas, and other substances.

A simple disinfecting powder may be prepared by well mixing carbolic acid with starch, lycopodium, or powdered charcoal, in the proportion of one part of the acid to twenty or thirty of the powder. Dr. Sansom recommends that the carbolic acid should be dissolved in about the same quantity of spirit before being mixed with the powder.

Chloride of aluminium under the name of *chloralum* has been recently introduced by Mr. Gamgee as a new disinfectant. It has great advantage over chloride of zinc and carbolic acid in not being poisonous, and the smell is not unpleasant. This substance is obtained by the double decomposition which occurs when solutions of sulphate of alumina and chloride of calcium are mixed together. By heating cloralum hydrochloric acid is expelled and alumina remains.

To Disinfect Bed and Body Linen.—A large tub should be always kept ready with a disinfecting solution, which will not rot or destroy, in which the soiled linen may be at once placed. A tablespoonful of Condy's fluid, chloride of lime, or Calvert's disinfecting powder, may be mixed with a large pailful of water. After remaining in this fluid for an hour or two, the linen, &c., may be transferred to boiling water, and should be boiled before it is washed.

Clothing may be disinfected by being suspended in a room into which the vapour of carbolic acid is permitted to diffuse, or by being placed in a close shutting box with bags of carbolic acid powder

between the layers of clothing to be disinfected. After being allowed to remain for a week or longer, they may be freely exposed to the air. Moderate heat greatly expedites the process of disinfection.

Heat is a valuable disinfectant, but is only available in a limited number of cases. Clothing and various substances may be thoroughly disinfected by exposure to a dry heat of 200° to 300°. No apparatus suitable for hospitals and workhouses working satisfactorily, has yet been completed, as far as I am aware.*

Practical Methods of destroying Contagious Disease Germs in the Air.—Disease germs can be separated from the air by filtration through cotton wool, as has been already mentioned on page 276, but practically it is not possible to carry out the process efficiently on a large scale; and although the patients and attendants might wear cotton wool respirators, the practical objections to such instruments are so numerous, and the idea itself is so very fanciful, that it is needless to consider the suggestion further. Moreover, the germs would only be collected, and not destroyed, by filtration through cotton wool.

* On the subject of disinfectants, the reader is referred to "Disinfectants, and how to use them," by Dr. Edward Wilson, of Cheltenham. The directions are printed upon cards, which are sold in packets of 12 for 1*s.*; published by Mr. Lewis, 136, Gower-street. These cards should be in the possession of all medical practitioners, clergymen, and others, whose duty and desire it is to prevent as much as possible the spread of contagious diseases.

Of the substances employed for the destruction of disease germs, only some are adapted for use in the sick chamber. The smell of chloride of lime is very disagreeable to some patients, and the sulphurous acid, although doubtless most efficient, would be injurious and quite intolerable if the patient's air tubes were at all irritable. Iodine vapour is efficient as an antiseptic, but it is doubtful if this is as destructive of disease germs as sulphurous acid or carbolic acid. Chloride of zinc, permanganates, and chloralum do not diffuse through the air. A dilute solution of one of these substances may, however, be made in a pail, and a large sheet well wetted, and then carefully drained. The wet sheet should be hung across the doorway in such a manner that any air passing from the room may traverse the surface before it escapes. Carbolic acid properly diluted may be used in the same manner. Disinfectants placed in saucers in different parts of the sick room are of much less use. But many substances whose antiseptic properties are doubtful, are highly efficient for removing putrescent odours. Charcoal has this property in a very remarkable degree, but neither this substance nor earth will destroy living disease germs. I believe the most efficient plan, both for removing offensive smells and for destroying living disease germs, is to cause the vapour of carbolic acid to be thoroughly mixed with the air of the sick room. Some strongly object to the peculiar odour, but the majority of

persons soon become accustomed to it, or do not dislike it even when they smell it for the first time.

The vapour of carbolic acid will diffuse itself through the air of the sick room or through the house very quickly if the acid be subjected to a moderate heat. A teaspoonful may be poured into a common garden saucer which has been previously warmed, and placed in the sick room. The operation may be repeated once in four or six hours.

Different forms of apparatus for effecting more conveniently the volatilization of carbolic acid have been suggested. Among these the most simple and efficacious is the self-acting vapouriser of Messrs. Savory and Moore, 164, New Bond-street. A metallic plate is kept warm by a small night light or small-wicked spirit lamp. By the aid of an ingeniously constructed syphon, carbolic acid is made to fall on the surface of the heated plate, drop by drop. It is instantly volatilized, and is soon diffused through the atmosphere. This instrument may be obtained ready for use at a moment's notice, and is, I believe, really efficient.

On destroying contagious Germinal Matter, after it has entered the Body.—Unfortunately, we are not yet acquainted with any means by which the contagious germs, which may be circulating in the blood, can be certainly destroyed, and the injury which necessarily results from their growth and accumulation in various parts of the system, prevented. But yet the facts of the case justify the hope that so desirable an end may

some day be attainable. The varying action of the same conditions upon different forms of bioplasm almost suggests the possibility that some agent which may destroy the contagious bioplasts circulating in the blood, without injuring the normal bioplasm of that fluid or that of the tissues, may be discovered. The introduction into the blood of some gas or vapour by the respiratory surface, or the absorption from the digestive canal of some compound which would be decomposed after it had passed into the blood, may be the means by which the desired end will be effected.

It has been too hastily assumed by some that any substance which would destroy a morbid poison, would necessarily so change the composition of the nutrient fluid in which it was suspended, as to render it unfit for the nutrition of the body. Such a conclusion, however, is neither supported by facts nor to be justified by theoretical considerations. It has been proved experimentally by Crookes that a solution of carbolic acid of sufficient strength to destroy the poison of cattle plague, may be injected into the blood of a living animal without rendering the blood unfit to support life. The rapid diffusion of certain soluble materials through the tissues of the body proves that living particles, even if embedded in the substance of the elementary parts themselves, might be reached by soluble material introduced into the stomach and afterwards absorbed by the blood. The living matter, or bioplasm, of which contagious disease germs consist,

is unprotected by any external envelope or cellwall, and would, therefore, be acted upon much more readily than the bioplasm of the tissues. In nutrition, the higher bioplasm, taking part in tissue formation, may be nourished, while a lower form, situated close by, may be starved, and even die and disappear. In certain abnormal conditions the very reverse obtains, the higher bioplasm having deteriorated, succumbs, while the lower rapidly increases and accumulates, until the normal tissue and its bioplasm are completely and irreparably destroyed.

Regarded from this point of view, the discovery of a plan of treatment which shall ensure the destruction of such forms of bioplasm as tubercle and cancer, appears possible. One can conceive that certain substances may be discovered which, if introduced into the blood, either from the stomach or injected into the areolar tissue, may destroy the active growing bioplasm of tubercle, cancer, and other pathological forms, or cause them to waste and degenerate, without in any way affecting the tissues of the body, or interfering with the general nutritive properties of the constituents of the blood.

And there are other directions in which we might work in the hope of obtaining similar advantageous results. It may be possible to find out the particular materials which morbid bioplasm appropriates, and expel these from the nutrient fluid, in which case the morbid, rapidly growing, bioplasm

will be destroyed, and this without that concerned in the healthy physiological changes being seriously damaged. Nay, is it not probable that some of our remedies really do act in this manner? It is well known that large quantities of chloride of sodium exist wherever bioplasm is growing rapidly; and it appears to me probable that the beneficial action of iodide of potassium and some other salts may be explained, if we suppose that the chloride is driven out and its place occupied by the iodide, which latter salt does not favour the growth of the morbid bioplasm, the rapid increase of which constitutes the local change we are endeavouring to check. The morbid bioplasm, deprived of one of the substances necessary for its increase, ceases to grow, and is soon destroyed when the products resulting from its death are removed, and the cure is complete. With regard to acting practically upon the foregoing suggestions, I would remark that it occurred to Mr. Crookes, when studying the cattle plague, that, as he could so successfully attack and destroy the floating disease germs by atmospheric disinfectants, he might so be able to neutralise the virus in the blood by the introduction into it of appropriate antiseptics, Dr. De Ricci, Professor Polli, Dr. McDowell, Dr. Waters, and others had advantageously used in this way sulphites and bisulphites as prophylactics and cures in zymotic diseases. The injection into the blood of carbolic acid (4 per cent. solution) was tried on an animal having cattle plague;

six ounces containing 105 grains of pure carbolic acid were introduced, the animal appearing to suffer no inconvenience from it after the first trembling, consequent upon the disturbing influence upon the circulation, had subsided. The cow gradually improved, and at length perfectly recovered.

Mr. Crookes very correctly observes that the theoretical views, the experiments, and results he has put on record, have an interest and bearing far beyond the sphere of cattle plague, applying, as every argument brought forward, and every result obtained in the course of his experiments does, with overwhelming force to such visitations as typhus and typhoid fever, small-pox, diphtheria, and cholera. The free use of such agents, or carbolic acid amongst us, he believes, might save the country, not only from the ravages of these pestilences, but go far to ameliorate the physical conditions of the people.

It seems a pity that this, a plan of treatment of such promise, should not have been tried upon an extended scale upon the contagious fevers of man. I believe that few people would object to live for days or weeks in an atmosphere impregnated with carbolic acid, for the smell is one of those to which we soon get accustomed, and endure without disgust. In the late war, there were many opportunities of putting to the test the value of carbolic acid, but I am not aware that the air of any one ward or room set apart for the reception of the wounded was kept constantly impreg-

nated with the vapour of carbolic acid. The question whether such a plan was efficacious in preventing the spread of erysipelas and hospital gangrene is one that might have been conclusively determined. A similar experiment ought to be tried as regards fevers and other contagious diseases. In ordinary hospitals there is considerable difficulty in carrying out such a plan. The patients themselves, or the attendants, or the committee may object to the smell, or feel indisposed to permit the consumption of a sufficiently large amount of the acid; and unless the experiment were tried thoroughly and carefully and continuously, day and night for some weeks or months, it would be impossible to arrive at the truth. It will, I think, be admitted that many of the circumstances referred to in these pages render it very desirable that such an experiment should be tried without delay.

On checking the too rapid growth of Bioplasm in the Blood and Tissues.—Effects of carbolic Acid and Sulpho-Carbolates administered internally.—It has been already shown (pp. 121, 218) that in all fevers and inflammations, the bioplasm in the blood and tissues increases more quickly than in the normal state. This undue increase is indeed essential to the states of fever and inflammation. Were the growth of the bioplasm not accelerated, there could be no "fever" or "inflammation." Were it possible to reduce immediately the rate of growth of the living matter, fever and inflammation already established would be *cut short*, and the patho-

logical action would give place to the physiological changes characteristic of the body or part of the body in the healthy state. The discussion of this part of my subject involves the question of treatment of the febrile state, which will be more conveniently deferred until the question of the use of the sulpho-carbolates in contagious diseases and in some other affections has been briefly disposed of (*see* p. 325). I propose, therefore, to consider the influence exerted by carbolic acid and its salts, when administered internally. It has been shown that the local application of carbolic acid and many other substances checks the abnormal growth and multiplication of bioplasm. Can we succeed in effecting a similar beneficial change in internal parts, and checking the redundant growth of bioplasm in the blood, and in the deep organs and tissues of the body, in certain internal inflammations and in the feverish state, by the introduction of any soluble substances into the circulating fluid?

Knowing the powerful influence of carbolic acid vapour upon contagious poisons, my friend, Dr. Sansom, was led to try the effects of various compounds of carbolic acid introduced into the stomach. Further experience is required before we can decide if these salts do actually destroy the contagious matter while it circulates in the blood; but, as my friend has obtained some very encouraging results, it is desirable that the attention of the profession should be at once directed to the subject, for it is only by engaging the interest

of a number of practitioners that the real value of remedial measures can be certainly tested. In the following pages I have given a summary of Dr. Sansom's paper on the sulpho-carbolates, published in No. XVII of my "Archives." The results will also be found in detail in his own book on "The Antiseptic System," just published, and to this work the reader is referred for a full account of Dr. Sansom's interesting observations.

Dr. Sansom remarks that a great number of antiseptics are capable of ready absorption into the blood. Such are carbolic acid, alcohol, sulphuric acid, sulphurous acid and the sulphites, many metallic salts, &c. It seems, however, that when these have been employed in times past, the rationale of their action has not been attributed to septicidal power. When in 1857, Prof. Polli, of Milan, introduced sulphurous acid and the sulphites, for the treatment of contagious fevers, he expressly declared his conviction that they did not act as poisons towards the supposed morbific ferments. It seems to have been accepted as a doctrine that it would not be possible to destroy such ferments, or to neutralise their influence, within the living organism, without modifying the character of the blood to such an extent as to imperil its power of sustaining life. If antiseptics acted in a purely chemical way, such an inference would be justified; but there is strong evidence against this chemical doctrine. The sulphites administered to living animals

prevent or greatly postpone putrefactive change in the body when the animals are killed, but nevertheless these salts are discovered in the tissues as sulphites still undecomposed. These facts alone lead to the inference that the *sulphites* do not act as mere deoxidisers, for if they did so, they would be discovered as *sulphates.* Experience has shown that a trace of sulphurous acid will arrest fermentive changes in a mass of material upon which its *chemical action* would be quite inappreciable. There can, therefore, be no doubt that the *modus operandi* of the sulphite is that of a septicide.

Carbolic acid has been recommended as an antiseptic medicine, and, though the evidence is conflicting, there are many who think highly of its usefulness when administered in zymotic diseases. It is absorbed into the blood even when it is applied, of course diluted, to the cuticular surface. When pure it has a caustic action upon skin and mucous membranes, and even when freely diluted it is very nauseous. Its combinations with albumen, alcohol, glycerine, fats, &c., have each different degrees of antiseptic action. It is probable, therefore, that its effects vary, not only with the medicinal adjuncts with which it is administered, but with the nature of the contents of the stomach at the time of its ingestion. It was therefore considered by Dr. Sansom desirable to employ some preparation or salt of carbolic acid for internal administration. The following paragraphs

have been taken from Dr. Sansom's paper, before referred to.

Sulpho-Carbolic Acid (Syn. Sulpho-phenic or Phenyl-Sulphuric Acid, $C_6H_6SO_4$ or $C_6H_5SO_4H$) is the compound acid resulting from the union, in equivalent proportions, of hydrated sulphuric acid and pure carbolic acid. Heat is evolved in the combination, the temperature being raised to 200° F., and the immediate result is a syrupy fluid which slowly deposits crystals. By slow crystallisation at low temperatures the pure sulpho-carbolic acid may be obtained in long, slender, colourless needles, which readily deliquesce in the atmosphere. It may also be obtained by exactly decomposing the barium sulpho-carbolate with sulphuric acid, filtering from the insoluble barium sulphate, and evaporating *in vacuo.*

Sulpho-carbolic acid has a sp. gr. of 1·288 ; its odour resembles that of carbolic acid, but is less intense ; heated to 400° F., it becomes of a bright red colour, and when cooled, is nearly solid ; it boils at 540° F., and at 560° is decomposed into a black amorphous inodorous mass. Nitric acid added to sulpho-carbolic causes immediate decomposition with violence.

Sulpho-carbolic acid is soluble in water, alcohol, and ether, in any proportions. Its solution reddens litmus, and gives, like the aqueous solution of carbolic acid, a beautiful mauve or purple colour, on the addition of a solution of per-salt of iron. The

reaction is much more manifest in the case of the double acid than in the case of carbolic acid itself.

The Sulpho-Carbolates are prepared from the pure acid thus obtained by saturation with the various oxides.

Barium Sulpho-Carbolate, Ba $(C_6H_5)SO_4 + 3Aq$, is prepared by adding to the sulpho-carbolic acid diluted with ten times its bulk of water, barium carbonate. The filtrate is to be slowly evaporated by heat, and allowed to crystallise. The resulting barium sulpho-carbolate is in colourless rhombic prisms, tending, like the other sulpho-carbolates, to cohere in spheroidal groups. It is very readily soluble in water and in alcohol.

Sodium Sulpho-Carbolate, $Na(C_6H_5)SO_4 + Aq$, is obtained by carefully neutralizing the pure sulpho-carbolic acid dissolved in at least six volumes of water with carbonate of sodium or caustic soda. The resulting solution should be slowly evaporated over a sand-bath or water-bath until a pellicle appears upon the surface; it should be then set aside to crystallise.

The resulting salt is in brilliant, colourless, rhombic prisms, having the characteristic tendency to cohere in rosettes, freely soluble in six times its bulk of cold distilled water, and in two-thirds its weight of boiling water; it is slightly soluble in alcohol, but not in ether. A strong heat drives off a portion of the carbolic acid, and an aqueous solution of the residue gives the reactions of sulphuric acid; at a red heat it

is consumed without flame. The pure salt is singularly tasteless, only possessing a very slight bitterness.

Potassium Sulpho-Carbolate, $K(C_6H_5)SO_4 + Aq.$, is prepared in a mode similar to that described for the sodium salt, neutralizing the sulpho-carbolic acid with potassium carbonate, or hydrate. *Ammonium Sulpho-Carbolate*, $NH_4(C_6H_5)SO_4 + Aq.$, is obtained by neutralizing with ammonium carbonate or ammonium hydrate (liq. ammoniæ). It crystallises usually in the form of rectangular plates, and generally resembles the potassium salt. *Magnesium Sulpho-Carbolate*, $Mg\,(C_6H_5)SO_4 + Aq.$—Prepared in analogous manner from magnesium carbonate, is usually a mass of small brilliant crystals, but by careful crystallisation it may be obtained in fine rhombic prisms. It is very soluble. *Calcium Sulpho-Carbolate*, $Ca(C_6H_5)So_4 + Aq.$—By neutralizing with calcium carbonate (pure precipitated chalk), this salt is obtained in a congeries of needle-shaped or feathery crystals of a brilliant white appearance, the interlacing network forming an exceedingly light spongy mass. It is soluble in its own weight of cold water. *Zinc Sulpho-Carbolate*, $Zn\,(C_6H_5)SO_4 + 7Aq.$—To prepare this salt, pure sulpho-carbolic acid may be saturated with zinc oxide, or pure zinc itself may be used, hydrogen escaping in the decomposition. Or to a filtered solution of 10 parts of barium sulpho-carbolate in three or four times its weight of water, a solution of six parts pure zinc sulphate dissolved in

three times its weight of water may be added. A slight excess of zinc sulphate should prevail, so as to completely precipitate the barium. The filtered solution is evaporated and allowed to crystallise. *Copper Sulpho-Carbolate*, $Cu(C_6H_5)SO_4$.—It is prepared by neutralizing with cupric oxide. It forms brilliant prisms of an emerald green colour. *Iron Sulpho Carbolates.*—It is probable that iron forms two distinct compounds with carbolic acid. *Ferrous Sulpho-Carbolate*, $Fe(C_6H_5)SO_4 + Aq.$ is prepared by acting on pure iron with sulpho-carbolic acid to neutralization and evaporating. *Ferric Sulpho-Carbolate*, has not been satisfactorily isolated.

General Characters of the Sulpho-Carbolates and Tests.—Each sulpho-carbolate should possess a definite and decided crystalline form, and should be perfectly transparent, entangling no organic *débris*. These salts should possess scarcely any odour of carbolic acid. All should yield perfectly clear solutions, which should give no precipitate with barium chloride. If a few crystals be boiled for a few minutes with nitric acid and then twice the bulk of water added, *Picric acid* in yellow glistening scales is thrown down, and the supernatant liquid gives a white precipitate with barium chloride, showing that sulphuric acid is liberated. If to a solution of a sulpho-carbolate, a drop of a solution of a persalt of iron be added *the clear liquid assumes a beautiful purple or mauve colour.* One sixtieth of a grain of sodium sulpho-carbolate is capable

of inducing the mauve tinge in a ferric solution. The sulpho-carbolates are all very stable compounds.

Therapeutical Importance.—As *direct* antiseptics the sulpho-carbolates do not occupy a high place. They are far less efficient than many other salts of the metals, especially the chlorides and sulphites. The sodium salt is many times less efficient as an antiseptic than free carbolic acid itself. The very unstable carbolates possess, for the amount of carbolic acid they contain, equal antiseptic power with carbolic acid itself; not so the sulpho-carbolates, which are compounds of great stability. It may be concluded that the direct antiseptic power of carbolic acid in a given compound is inversely as the stability of the compound.

Comparatively with the other sulpho-carbolates the sodium sulpho-carbolate manifests the chief power in arresting saccharine fermentation. As this salt is, even in a strong solution, exceedingly tasteless, it was chosen for internal administration.

Two guinea pigs were fed with pills composed of arrowroot mixed with sodium sulpho-carbolate. No other food was given. In four days the little animals consumed 275 grains of the salt. No obvious effect was produced, except a slight looseness of the evacuations. The animals were killed and examined; no morbid lesion was found, but the duodenum of one contained an unusual quantity of yellow bile. On chemical examination the muscular tissue, the liver, and the urinary bladder yielded sulphate of sodium;

but neither sulpho-carbolic, nor carbolic acid, was evident to tests. The flesh showed a marked tendency to resist putrefaction.

Dr. Sansom found that 20 grain doses of sodium sulpho-carbolate could be readily administered to adults. The dose was increased in some cases to 60 grains administered every four hours. The only direct effect noted was a slight vertigo or dizziness. The odour of carbolic acid could be readily detected in the breath. The urine of a patient, who had taken 360 grains of sodium sulpho-carbolate in 24 hours was collected and examined. It presented no evidence of the presence of carbolic acid, but contained a considerable quantity of sodium sulphate. It resisted putrefaction.

It would appear, therefore, that sodium sulpho-carbolate administered to a living animal is rapidly absorbed and carried throughout the system. In the blood, or the tissues, the double salt is decomposed, the sodium sulphate being set free in the tissues, and ultimately excreted by the kidneys. The carbolic acid also liberated in the textures, for the most part escapes by the lungs. It is probable, also, that some portion of the carbolic acid is eliminated by the urine. The administration of sodium sulpho-carbolate is, therefore, an indirect means of introducing carbolic acid ; and, inasmuch as at least one-fourth of the weight of the sulpho-carbolate employed consists of carbolic acid, we find that an amount of the latter

equalling from 15 to 90 grains per diem can be administered. The direct administration of this amount of carbolic acid would, from its nauseous character, and its toxic action, be impossible.

I. *Sulpho-Carbolates of Alkaline Bases.*—Of these the *sodium sulpho-carbolate* has been the most largely employed. *Dose.*—The usual dose for adults has been ℈j every three or four hours; in some cases it has been increased to ʒss or ʒj. For children of 7 years of age 10 grains has been a usual dose.

The following results have been recorded by Dr. Sansom:—

Of 14 cases of ulceration of the tonsils the throat symptoms had completely disappeared: in two cases in three days: in nine cases in 4 days. The other cases were not observed till the end of 7 days. They were then quite well.

In three cases of *sloughing ulceration of tonsils* the treatment by the internal administration of ten grains of the sulpho-carbolate every four hours was successful.

Dr. Sansom makes the following remarks upon the use of the sulpho-carbolate of soda in scarlet fever:—

"The following is an analysis of 22 cases; some of them were of great severity. In one case, a boy of 7, there had occurred a sudden subsidence of rash, which had previously been profuse; epileptiform convulsions; much tumidity of neck and extrusion of discoloured mucus from the nose. Temp. 105° F. As soon as subsidence of convulsion permitted swallow-

ing, 15 grains of sodium sulpho-carbolate were administered every alternate hour. Following day, improvement, rash profuse, throat signs severe. Temp. 103·°6. Fourth day perfect power of swallowing: child sat up and amused himself with painting. Recovery uninterrupted and uncomplicated.

"In a second case, manifesting profuse rash, the signs of prostration which had been marked at the onset subsided, so that the little girl (aged 7) during the pyrexial stage while the rash was fully out, was permitted by her parents to run about the room and play with her toys. In this case the most profuse desquamation followed.

"The mean temperatures in a third case, wherein the throat signs were very severe, were, sixth day of fever, 104° F.; seventh day, 105°; ninth day, 101°; eleventh day, 97°. The throat symptoms passed away, leaving perfect power of swallowing, in five cases in 4 days. Complete convalescence took place in five cases in 7 days; in two cases in 11 days; in almost all the others in 14 days. The only sequelæ observed were in one case, albuminuria appearing on one day and disappearing by the next; in one case general anasarca; in one case abscess of a superficial gland in the neck; and in one case, a small persistent glandular swelling without suppuration. Not one of the 22 cases was fatal."

Enteric Fever.—Dr. Ligertwood, of Newbury, has employed the sodium sulpho-carbolate, in conjunction

with quinine, in an epidemic of severe typhoid. Twenty-four cases were thus treated, with three deaths. Dr. Ligertwood says, "I think the treatment was very successful. There did not seem to be the same tendency to relapse that I have found under other treatment. The diarrhœa, often very severe, never became so exhausting as to call for any special treatment."

Dr. Sansom has also given the sulpho-carbolate in about one hundred cases of phthisis. In many there was a very decided increase in weight soon after the remedy was commenced. Although indisposed to attribute the favourable results entirely to the effects of the sulpho-carbolate, upon the whole, Dr. Sansom has been led to conclude that it really acted beneficially.

II. *Sulpho-Carbolates of Alkaline Earth Bases.—Calcium Sulpho-Carbolate.*—Quite apart from any faculty as an indirect means of administering carbolic acid, this salt has a property which renders it peculiarly valuable for administration in certain diseases. In cases in which the osseous system is deficient in lime salts, it has always been a problem to find a lime salt which shall be readily absorbed by the vessels. The difficulty with regard to the ordinary medicinal lime preparations is their insolubility. Calcium-carbonate is not sensibly soluble in water; the phosphates are insoluble; and a pint of water at 60° F. will only dissolve 11 grains of calcium hydrate. The calcium

sulpho-carbolate on the other hand is perfectly soluble *in its own weight of water*, and it can be administered and absorbed with the greatest ease. Calcium sulpho-carbolate has been administered, combined with ordinary chalk mixture, in the treatment of the diarrhœa occurring in unhealthy children. The dose given was from three to eight grains three times a-day. The patients, concerning whom these results were recorded were out-patients of the North Eastern Hospital for Children; these, almost entirely, were dwellers in the poorest and most insalubrious parts of the East of London, Shoreditch, Bethnal Green, &c. The duration of the diarrhœa was manifestly controlled.

In the 22 cases recorded, which were taken without any selection, there is an almost universal history of improvement. The gain in muscular power was very evident, and the bones lost all signs of undue flexibility. In a single instance, the medicine was omitted because it seemed to induce pallor. In two instances, death occurred from convulsions subsequently to the discontinuance of the treatment.

The *zinc and copper salts* have been employed in aqueous solution as lotions for the treatment of wounds by Mr. John Wood. Thus employed, in proportions of 3 to 5 grains to the ounce of water, Mr. Wood considers them valuable for their antiseptic qualities. Wounds are kept clean and free from smell. Mr. Wood has also used the solutions as injections in gonorrhœal and other discharges, and as a dressing for superficial

venereal sores.* Like testimony comes from various American Surgeons.†

Iron Sulpho-Carbolate.—This has been largely employed in the treatment of affections in which other iron salts have been recommended. The dose for adults has been 10 to 15 grains. In children the dose has been 2 to 3 grains after the first year. The chief value of the salt has been seen in impetigo and the skin affections of ill-nourished children. In tubercular and pretubercular affections it has produced no marked benefit, the results being far inferior to those of the administration of the sodium salt. In external scrofulosis it seems to have been of advantage.

I have myself given the sulpho-carbolate of soda in several cases, and, although I am not at present justified in expressing a decided opinion that the benefit observed was entirely due to the sulpho-carbolate administered, I am quite convinced that the treatment is well worthy of being still further carefully tested. I have given the salt in doses of twenty grains with plenty of water three times or more a day in several cases of fever, erysipelas, and blood poisoning that have unquestionably progressed most satisfactorily ; but, until I have had further experience of the treatment in a considerable number of very bad cases, I cannot

* On the topical treatment and dressing of wounds "Practitioner," October, 1868, p. 208.

† "American Journal of Pharmacy." *See* "Pharmaceutical Journal," July 16, 1870.

feel convinced that the recovery of the patient was due to the influence of the sulpho-carbolate. The following cases are, however, of interest. A girl, who had a large abscess above the left mamma, connected with a carious rib, and whose life was in great jeopardy for a month or more, got quite well. The abscess was opened by Mr. Wood. Air passed from the lungs freely into the cavity of the abscess, and pus from the latter was expectorated in quantities. Another girl had a large abscess in the axilla, followed by secondary formation of pus very deep in both thighs. About a pint of fetid pus was removed from each abscess, and the cavity injected by Mr. Wood with carbolic acid water. Neither of these were promising cases, but both got well. They were treated carefully, and sulpho-carbolate of soda was given throughout the illness, in twenty grain doses three times a-day. A very bad case of inflammation of the knee-joint following acute rheumatism, and accompanied by hectic, night sweats, and emaciation also did well, although the patient was in a very critical state for nearly two months. Two cases of pyæmia also recovered, which I feared I should have lost—in fact, all the symptoms were as bad as those in other cases occurring in my practice, and which proved fatal. I purposely avoid tabulating these cases or giving minute details, for I am not desirous of deceiving myself or others concerning the treatment of disease, and would rather trust to the general impres-

sion on my mind concerning the utility of this plan than to the apparently more accurate evidence which is obtained by tabulating a number of cases. It seems to me that at any rate we shall be less liable to be misled concerning the value of remedial measures if we avoid making tables in the first instance. This plan is most valuable to test the truth of general inferences, but statistics of the action of remedies in a very limited series of cases of disease must always be received with caution; for, when once the process of tabulation is commenced, the desire to prove something definite becomes almost irresistible even to an unbiassed observer, and a very exaggerated importance may be given to facts which are, perhaps, susceptible of an altogether different explanation.

Of Resisting the Assaults of Disease Germs.

As stated on page 85, it would be futile to attempt so to protect our bodies as to render them unassailable. A knowledge of the minute size of disease germs, and the many ways in which they may be carried from the seat of their development, their power of living under adverse circumstances, and the many channels through which they may pass from the surface of the body and gain access to the blood, are circumstances which lead us to conclude that no matter what precautions we may take, we cannot certainly succeed in escaping attack. But whilst hundreds and thousands of persons must be exposed to the

influence of these living, growing particles of contagium, only one here and there ever becomes conscious of the fact by the phenomena which after a certain interval of time ensue in his organism.

To avoid all sources of danger is simply impossible under the conditions of present existence. Cabs, clothes, furniture, books, toys, and many other things, air, water, food, and milk, have acted as carriers of contagious poisons. But besides this, there is no doubt that infectious material has been conveyed by our domestic animals; and there is reason to think that flies, and probably smaller insects, sometimes convey disease germs from the infected to the sound. At the same time these facts ought not to cause alarm. While it would be wrong on the part of any one to expose himself needlessly to risk, it would be silly to be always fearing invasion. The fact of the escape of the attendants of the sick, in spite of their continual exposure, ought to be sufficient to relieve the alarm of the most timid, and prove to them that exposure does not imply contraction of disease. We are continually exposed, but it is only very rarely the exposure results in the slightest disturbance of the healthy changes of the body. We must conclude that the germs by which we are assaulted almost invariably die or are even destroyed by the fluids of the organism itself. The body in its normal state of health has a power of resistance; and the fact that many members of the medical profession and nurses,

although exposed time after time to the influence of contagious disease, reach old age without having suffered from a single attack, ought surely to encourage and afford a justification to those who, having determined to devote themselves to the service of the sick, must be continually exposed to contagion. At the same time these facts point to another very important conclusion, namely, that we may keep our bodies in such a state as will enable them to bear free exposure with little danger of invasion. But, unfortunately, the knowledge we have at present is not sufficient to enable us to indicate precisely either the state of the system or of the blood, which would certainly enable us to resist the influences of the contagious particles, or the state in which it would be extremely dangerous to expose ourselves to the poison. Without doubt, persons whose health is impaired, those who are actually suffering from, or who have recently become exhausted by prolonged watching, mental anxiety, or over fatigue, should avoid the sick who are suffering from any form of contagious fever. A state of health which for some time has been characterized by loss of appetite, with nervous listlessness, wakefulness at night, and muscular weakness, seems particularly to favour invasion by contagious poisons. On the other hand, those who seem frequently to be ailing, and who suffer from that condition known as biliousness, certainly often, though it cannot be said invariably, escape although freely exposed.

Every one who is attending contagious fevers, cannot be too careful to keep all his secreting organs in a state of healthy activity. The bowels, the kidneys, the skin, should act freely. He should be out in the open air for at least three hours out of the twenty-four, should have plenty of good food at regular hours, a moderate allowance of stimulants (four ounces of port or sherry), if he takes stimulants habitually, and should have rather more sleep than he takes ordinarily. Such points should be carefully borne in mind by all who nurse the sick. And those who engage nurses should have their attention directed to the importance of making such arrangements as will permit these suggestions being carried into practice. It is conceivable that a population might exist among whom fatal contagious disease would not spread even if it were introduced, but there is, I fear, little hope that these terrible maladies will be extirpated, their germs destroyed, or even the development of new ones prevented, during the life-time of any one now living. It is, therefore, necessary to consider how the medical treatment of those attacked should be conducted, in order to afford the best prospects of recovery.

On the Treatment of the Febrile State.

The feverish condition which is caused by the entrance of disease germs into the organism, and their transmission by the fluids of the body to all the tissues and organs, is essentially similar to that feverish state which not unfrequently originates in changes occurring in the body itself, without being occasioned by the ingress of anything from without. In considering, therefore, the principles which should guide us in the treatment, it will be necessary to discuss the influence of remedies upon the feverish condition generally, irrespective of the causes which may have given rise to it; and it will appear that there are certain general facts of the highest importance, the proper estimate of which will lead to the adoption of certain measures of great practical value in all forms of fever, and which have to be considered even in special cases which demand peculiar and, it may be, exceptional measures.

In conducting the treatment of fever due to the presence of disease germs, we have to determine by what means the patient's life may be preserved while he remains a sufferer from the conditions caused by the growth and multiplication of the living poison within his body, or from the lesions which follow in consequence of this process, which may be brought about during the elimination from the organism of the

substances resulting from the death of disease-germs and of other forms of bioplasm.

On Treatment based upon the fact of the Rise of Temperature.—Acting upon the hypothesis that the danger to life from fever depends upon the increased temperature, many physicians have adopted plans of treatment which have for their object the carrying off heat from the surface. This is accomplished by the external application of cold. Although there is evidence that cold to the surface does good in some cases in which the body-heat is above the normal standard, few physicians feel sufficiently satisfied that conclusive proof has yet been adduced in favour of the view that this indication for treatment can be with wisdom fearlessly followed out in all cases.

This remarkable increased development of heat in all fevers is probably an immediate effect of another change. It is certainly associated with, and (I believe) due to, very rapid growth of bioplasm, principally in the slow-moving blood in the capillaries; but the bioplasm in the tissues external to the capillaries is also involved, and in some fevers in a very remarkable degree.* The increase of the bioplasm continues, as does also the development of heat, for an hour or two (and in rare instances for a much longer period) *after death*, and occasionally up to a certain time even in an increased ratio; and for this reason:—The bioplasm being perfectly still, and

* *See* my "Report on the Cattle Plague." 1866.

everywhere surrounded by nutrient pabulum, is under the most favourable conditions for appropriating rapidly all that lies sufficiently close to it ; it therefore rapidly increases until the adjacent pabulum is exhausted. But when this happens, as no fresh nutrient fluid can possibly be brought to it, the bioplasm dies, and the temperature soon falls.

Now (as will be presently explained), there is reason to think that many of our remedies act beneficially by the direct influence they exert upon the process of increase of the bioplasm in the blood and in the tissues. In fever and certain low states of the system, the bioplasm of the tissues and blood invariably increases more rapidly than in health ; and, as I showed many years ago, the classes of remedies which experience has proved to be beneficial are those which check the growth of bioplasm. Stimulants effect this object quickly, and many of the so-called tonics possess this property in a very remarkable degree, though they act more slowly.

Cold reduces the temperature, and may also be instrumental in bringing about a state of things unfavourable to the growth of the bioplasm, which is the immediate cause of the rise. If, however, we could prevent the undue growth of the living matter, or check it before it has proceeded to a dangerous degree, the temperature might not rise so high as to render the external application of cold either necessary or desirable. If we proceed back yet another

step in the inquiry, we shall find that the multiplication of the masses of germinal matter or bioplasm is due to the rapid appropriation of excess of pabulum. If, therefore, this pabulum were removed, or its constitution changed, or its formation prevented, there is reason to think that the increase of the bioplasm would be stopped, in which case the feverish state could not be established. Or, if the blood could be urged more quickly through the capillaries, the heat developed would be carried off, and pass away latent in vapour from the skin and lungs. The rise in temperature would not take place so long as the increased rate of the circulation compensated in this manner for the undue development of heat. This remark will appear strange to many readers who attribute increased body-heat to increased oxidation; but there can be no doubt that the conclusion I have drawn is correct, for does not the temperature invariably rise as the capillary circulation becomes *more feeble*, and, as already remarked, often obtain its maximum some time after the blood *has ceased to circulate at all*—when, in fact, the functions of respiration and circulation, which are specially concerned in oxidation, have ceased?

Of the Mechanism concerned in equalizing the Temperature.—In *health* any disturbing influences are compensated with remarkable rapidity. Thus, exposure to degrees of heat or cold differing considerably from the body-temperature will produce very slight change in the internal temperature. The same thing

is observed as regards alcohol. In the experiments of Parkes and Wollowicz, moderate doses of alcohol appeared to influence very little the temperature of the body or the amount of nitrogen excreted. Traces of alcohol escaped, but there can be no doubt that the larger proportion was appropriated by the bioplasm of the blood, and afterwards eliminated in the form of excrementitious matters, especially carbonic acid and water. But in fevers and inflammations the mechanism by which this process of compensation is carried out undergoes deterioration or is seriously damaged, so that artificial efforts are required to put it into operation at all. In health it works perfectly well without the introduction of any stimulants or other substances from without.

The manner in which this compensatory action is effected has been described in my Croonian Lecture (*Proceedings of the Royal Society*, May 11, 1865), and before this in a memoir "On Deficiency of Vital Power in Disease, and on Support," published in the *British Medical Journal*, for 1863. The following extract will serve to explain the matter :—" If you press upon the distended vessels of an inflamed part, as is well known, the blood is driven out of them, and the skin becomes quite pale ; but the moment the pressure is withdrawn, the redness recurs, and exhibits precisely the same tint as before. From this it is clear, not only that the capillaries are distended, but that the calibre of the small arteries through which the blood

is distributed to them is much larger than in the normal condition. Besides this, the simple experiment proves that the vessels *are maintained for a long time of a given calibre.* Such a state of things can only result from the influence of nerves which govern th calibre of the small arteries ; and thus the quantity c blood permitted to flow through them in a given tim is regulated and varied from time to time. Th mechanism is such that a small artery is made t assume a different calibre, although this may be mo mentarily altered by artificial means. I have shown contrary to the statement of Kölliker, that *all* th small arteries are abundantly supplied with nerves, and that nerves also ramify in the tissues external to the capillaries, and upon the capillaries themselves.

There are the *two* kinds of peripheral nerve-fibres which take part in regulating the supply of nutrient pabulum to every part of every tissue in the body :—1. The nerve-fibres distributed to the coats of small arteries and veins which ramify upon, and amongst, their muscular fibres. These are *afferent* or *motor.* 2. The nerve-fibres distributed to the capillaries, and in tissues which are altogether devoid of capillaries. These are the *afferent* or *excitor* branches and are connected with the centres from which the vaso-motor nerves arise. These branches have been demonstrated by me in many tissues, and form a new system of nerve-fibres, not previously described. (*See* "Archives," No. xiii.) Now,

any alteration taking place in the nutrition of the tissue-elements external to the capillaries must of necessity influence these excitor or afferent branches. The fibres may be subjected to increased or diminished pressure, to the influence of an increased or diminished quantity of fluid; and their numerous masses of bioplasm will necessarily be exposed to the same conditions as those of adjacent tissues. In the inflamed tissue, the bioplasts, like those of the tissues around, would receive more pabulum, and would grow faster; and where growth and increase of living matter are most active, the particular action or function of the tissue is least manifested, because function is the effect of changes in matter which has been already *formed.* Hence it is not when nerves are *growing* that we find nervous action remarkably developed, but when they *have grown.* So in the case supposed the nerves are less active than in the normal state, and, as a consequence of their inactivity or reduced irritability, we have dilatation of the vessels. A further development of the same changes will lead to paralysis, and ultimately the complete destruction of the normal tissue will follow unless the balance of nutrition is restored or death is occasioned.*

The beneficial effects of external cold in febrile conditions have been long known, and cold was prac-

* *See* also a paper "On the Distribution of Nerves to the Capillaries and their Action in Health and Disease."—Microscop. Soc., Dec. 6, 1871; published in the *Monthly Mic. Journ.* for Jan., 1872.

tically employed in the treatment of fever by Currie so long ago as 1789.

Effects of external Cold in Fever.—Of late years the more careful employment of the thermometer in disease, has proved to be of great value, especially by the observations of Traube, Wunderlich, Ringer, and others, and now carried out by the great majority of practitioners, both in public and private practice, has, as might have been anticipated, led to a revival of the treatment of fevers by cold. In order to form a correct judgment concerning the influence of cold upon the phenomena of fever, I would refer to the results which have been observed to succeed its application in cases of extreme severity, and I doubt if any more to the point could be selected than the cases which have just been published by Dr. Wilson Fox.* I desire more particularly to call attention to these cases, because they also afford an illustration of the free use of stimulants in the very last stage of desperate fever, at a period of the disease when the temperature was so high that a fatal termination was imminent; indeed, it is almost certain that death would have occurred had not the most decisive measures been promptly taken.

Excessive and very rapid rise in temperature is perhaps seen more frequently in acute rheumatism than in any other febrile disease. In very severe cases of this affection it is not uncommon to find a

* "Treatment of Hyperpyrexia." Macmillan & Co. 1871.

rise of 4° or 5° within a period of a few hours, death usually taking place a short time after a temperature of 107° has been reached, and sometimes before so high a maximum has been attained. The high temperature may persist for some time after death, and a further (post-mortem) considerable elevation has been witnessed. It is, indeed, seldom that recovery occurs after the temperature has reached 106° in a case of acute rheumatism; but Dr. Fox gives a full account of two remarkable cases of the disease which recovered after a temperature of 110° in the one and 107·3° in the other, had been attained. Both these cases were treated by the application of cold. In the first, when the temperature was 107°, the patient was immersed in a bath at 96°. The temperature, however, still rose until it was 110° in the rectum, when "ice was fetched; a large lump was placed on her chest, another on her abdomen; a bag filled with ice was tied down the length of her spine; and while two assistants baled the warmer water out of the bath, two others poured iced water over the patient as rapidly as the pails could be filled." *Within half an hour the temperature in the rectum had fallen to* 103·6°, *and in less than another half-hour to* 99·5°. It is, however, worthy of note, that the patient took *six ounces of brandy* while the ice and cold water were being applied, during one hour, when the temperature fell more than 10°. Subsequently eighteen ounces of brandy per diem were given for several days.

In Dr. Fox's second case, also, in which the temperature was reduced from 107° to 98° within an hour, large quantities of brandy (from twenty-four to twenty-eight ounces in twenty-four hours) were given, and Dr. Fox expresses a doubt whether the man would have recovered at all had the stimulant been withheld.

In a case of Dr. Meding's*—quoted by Dr. Fox—the temperature fell from 108·6° to 99·5° *in five hours* during the application of ice-cold cloths to the body, and enemata of iced water given every half hour. The pulse fell from 140 to 72, perspiration ensued, and the patient rapidly recovered. In this case no stimulant at all was administered, but the temperature fell much more slowly than in Dr. Fox's cases. It was certainly slight as compared with the two cases reported by Dr. Fox, and with many that I have myself seen, and treated successfully with frequently repeated doses of brandy without recourse to the application of cold.

Dr. Wilson Fox considers that in acute rheumatism active treatment by cold should be commenced when the temperature reaches 107°, and all physicians who have had much experience in the treatment of desperate cases of the kind will be disposed to agree with him; for although the opinion may be fairly entertained, that in many cases the rise of temperature to the danger-point may be prevented by treatment, and

* *Archiv. für Heilkunde*, 1870, xi., p. 467.

particularly by the administration of alcohol, it appears to me to have been fully proved that cold (with or without stimulants) is the only remedy yet tried by which the rise in temperature can be not only quickly checked, but decidedly and rapidly reduced after the high body-heat of 107° has been reached. In moderately severe cases many will doubt if there is any necessity for adopting the treatment by cold; and it is certain that many most serious cases have progressed favourably, and have recovered, under other plans of treatment, and especially under the influence of alcohol. But in such very serious instances of disease as those reported by Dr. Wilson Fox, there can be no doubt that the application of cold should be resorted to. The objections that can be made to the plan are, in my opinion, far outweighed by the circumstance that, if not adopted, the patient will almost surely die, and within an hour or two.

By merely reducing the temperature of the body, however, we do not remove the causes which have given rise to the increased development of heat. The rise in temperature is not the *cause* of the feverish condition, but a concomitant effect, or a consequence of a prior change—the increase of bioplasm. At any rate, in every one of the cases of fever that I have examined, both in man and animals, I have invariably found very considerable increase in the proportion of the bioplasm of the blood and tissues. (*See* page 111). If the bioplasm did not increase, there would have

been no undue development of animal heat—no fever. This, then, seems to be the change of which the febrile or inflammatory state is an immediate consequence, and it is therefore of the utmost importance to consider carefully the various means at our disposal for preventing or modifying, or cutting short the conditions which favour the occurrence of such a morbid change, or which may modify the intensity of the latter when it has occurred. It is also highly desirable to discuss the circumstances which, in severe forms of disease, occasion the fatal result, either suddenly or more gradually, by inducing structural changes which render impossible the continuance of life.

In very severe cases of fever, what we have to apprehend, and that which our greatest efforts should be directed to avert, is, *stagnation of the blood in the small vessels, and cessation of the capillary circulation over a considerable part of the body.* To bring about this result, the following circumstances contribute:—

1. Failure of the force of the heart's action.
2. Alteration in the composition of the blood.
3. Growth of the bioplasm of the blood, vessels, and tissues.

I. *Failure of Heart's Action.*

In many severe attacks of fever, the danger to life depends upon the weakness of the heart's action; and of those who succumb to fever, not a few are known to have had a weak heart. Such a condition of the

organ is often congenital, and not unfrequently associated with it we find that degree of vigour as regards the ganglionic nervous system which, although consistent with prolonged, steady, and equable work, is liable to fail if the demand for greatly increased activity should arise. The cardiac mechanism especially may be well adapted for the ordinary requirements of the system in health, but, nevertheless, unable to bear a strain, and quite incompetent to discharge double duty even during a short period of time. Many persons who are capable of performing steadily and regularly a moderate amount of labour without suffering, and who may perhaps continue to do so, without being laid up for even a short time, and reach, in fair health, the period of life when the capability to labour ceases, would be much deranged, and perhaps made seriously ill, if double or treble the amount of work were suddenly thrown upon them. In all cases of fever it is important that the physician should endeavour to form a correct estimate of the heart's healthy power. By good management we may be able to keep steady the force of the circulation throughout the whole period of the malady. During a critical period it may be necessary to excite the organ to increased action by stimulants; and at another time it may be desirable to pour in highly nutritious food instead of stimulants. In this way we may improve the health, and gradually renovate the strength.

There are cases in which, by the failure of the

heart to propel the blood with sufficient energy through the capillaries, the patient's life is for a time in great jeopardy. By timely and active measures, we may succeed in exciting the heart to more vigorous action and the patient may be successfully conducted through a very dangerous period of the malady. In all cases of fever it is important to watch very carefully for any indications of decided failure of the heart's action; but, at the same time, it is very necessary not to modify the treatment at every slight change that may be noticed in the force of the pulse.

In slight febrile affections, the heart's action is usually sufficient for the work it has to do during the fever. If the feverish condition lasts more than a few days, and the organ contracts feebly, its vigour may often be restored by the administration of small quantities of easily digested food at very short intervals of time. Two or three teaspoonfuls of milk or strong beef-tea every two hours during the night, as well as during the day, may be given, and a little wine may be ordered, if food alone does not have the desired effect. But if, in cases of fever which continue for a fortnight or more, we find the heart's action becoming decidedly weaker, it is necessary to stimulate artificially, at least for a time. A stimulating action is produced by certain remedies which act through the nerves. Stimulating liniments or turpentine externally will sometimes succeed. Remedies which stimulate the olfactory and respiratory portions of the

mucous membrane act in the same way; but the most direct as well as the most efficacious means, is to introduce stimulants into the stomach. These also act beneficially in several other ways. Ammonia, chloric ether, and various kinds of alcohol (when given not too much diluted) produce an immediate though indirect influence upon the force of the heart's contraction. The usefulness of this practice is proved by the fact that very soon after a little wine, brandy, or ammonia has been taken, when the heart is acting very feebly, as during a partial faint, or from the influence of chloroform inhalation, the vigour of the heart's contractions becomes sensibly increased. The change is often noticed within a few seconds after the stimulant has come into contact with the mucous membrane of the stomach. This action is, no doubt, reflex, and is due to an influence produced upon the ganglia of the sympathetic, an impression being transmitted by afferent nerve fibres from the skin (mucous membrane) of the nose, throat, respiratory passages, or stomach, as the case may be, to the ganglion cells. Immediately an impulse is transmitted from the ganglia along efferent fibres distributed to the muscular tissue of the heart which contracts more strongly, and, in consequence, the blood is propelled with greater force through the arteries and capillaries of the body generally, and the tendency to death from this cause is at least postponed, and possibly averted.

II. *Alteration in the Composition of the Blood.*

In this place we have to consider how we may prevent the textures and organs of the body being damaged, and life destroyed, by the altered blood circulating in the vessels: and we must also inquire whether we can, by judicious interference, promote and accelerate the restoration of the nutrient fluid to its normal state.

It was formerly supposed that the chief thing to be guarded against in the treatment of fever was undue oxidation; but later investigations have proved that fever itself is due indirectly to changes which are consequent upon insufficient oxidation; and it is, indeed, probable that a febrile state may be engendered by a long continued insufficiency of this most necessary change. It is doubtful if the feverish state could exist in an organism in which the oxidising processes were performed perfectly and at a proper rate.

There is good reason to think that if the noxious materials which accumulate in the blood in fevers and extensive internal inflammations could be more fully oxidised, they would soon afterwards be eliminated in the form of urea, carbonic acid, and other excrementitious matters which at last result from the destruction of bioplasm and the oxidation of the products of its death; but while these excrementitious matters, or the imperfectly oxidised materials from which they are immediately produced, continue to

accumulate in the blood, the excreting organs cannot eliminate them or alter them fast enough. In many instances the excreting glands may be excited artificially to increased action ; and it is in this way that many diuretics, sudorifics, and purgatives often afford great relief, and restore the patient to health. But in serious cases, in which the strength is already much exhausted, more especially if the fever has yet a long course to run, there would be danger in pushing too far the use of such remedies. Moreover, the excreting organs cannot excrete all these unoxidised animal substances in the state in which they exist in the blood. In not a few instances in which the noxious materials have unduly accumulated, it will be found that the secreting organs *cannot be made to act;* as the afferent nerves (*see* page 330) are in part paralysed, our remedies are powerless. To give excessive doses in such cases would be very unwise, and by so doing we should render the condition worse.

Under the circumstances indicated, however, there is danger of the imperfectly oxidised substances accumulating in the blood and in the tissues to such an extent as to place the patient's life in great jeopardy And the danger is twofold. In the first place, many of the bodies in question are unstable compounds, and liable to decompose at the temperature of the living body. The products of decomposition set free in the blood would very soon destroy the living matter of the blood and tissues, and paralyse and destroy the nerve-

fibres and nerve-centres, in which case the patient must die. But secondly, if the compounds which cannot be excreted in the form in which they exist are not to undergo decomposition, they must be quickly taken up and appropriated by the living bioplasm of some sort. As the bioplasm of the excreting organs is already surcharged even to such an extent as to endanger the integrity of the organs by increase of its bulk, and in other ways, the living matter of the blood, and then that of the tissues of the body, begins to appropriate the excess of pabulum. The white blood-corpuscles increase in size, and divide and subdivide, the minute particles of bioplasm (*see* p. 134) grow and increase in number, and the bioplasts of the tissues enlarge, and many new centres (nucleoli) make their appearance in them. *But these phenomena cannot occur without the action of the tissues being seriously impaired; and worse than this, the increase of bioplasm in the blood inevitably leads to impeded capillary circulation*, and to stagnation of the fluids in the substance of all the tissues of the body —the result of which, if local, must be destruction to the part of the tissues involved; if general, fatal to the whole organism.

But nevertheless, of the two circumstances just spoken of—1, the decomposition of albuminous matters, and 2, the excessive growth of the bioplasm—the latter is by far the least dangerous, for the first is almost necessarily fatal, and rapidly so.

Under favourable circumstances, much of the noxious substances which have accumulated may be removed from the circulating fluid by the growth of the bioplasm, and thus temporarily stored in the form of living matter. Time may be gained for the excreting organs to right themselves, and that most favourable symptom in all cases—free excretion—may occur, in which case the surcharged bioplasm becomes at once reduced in volume, and is ready to appropriate more of the dangerous pabulum. The blood is thus relieved. Its bioplasm then takes up the excess of pabulum in the tissues, the bioplasm of which gradually returns to its former volume, and there is every prospect of the normal balance of the nutritive and destructive processes being gradually restored. If, however—as but too frequently happens—the proportion of the noxious matters already formed be very great, the bioplasm continues to increase unduly; and, as has been mentioned, it is this increase which not unfrequently determines the fatal result. But still, the state of things established by the undue growth of bioplasm, unlike that resulting from putrefactive decomposition, is not immediately or *necessarily* fatal; and if by the process life is destroyed, that event is considerably postponed.

III. *Growth of Bioplasm.*

This, as will have been inferred from the remarks under the last heading, is a very serious change, very characteristic of the febrile and inflammatory state, and it is that which most frequently leads to a fatal result, and even when recovery takes place, the increase of the bioplasm may occasion impaired health or chronic disease. The change was referred to in my "Report on the Cattle Plague," published in 1866, and before that time had been fully described in my lectures at King's College. The alterations are most remarkable, and have been figured in numerous illustrations (*see* plate XXVIII., p. 218). It is this process of undue growth of bioplasm, which from the first we must endeavour to control by treatment. We must try to establish those conditions from the first which we know to be unfavourable to this process. Although it is some years since I pointed out this most important fact, and laid great stress upon the increase of bioplasm in all fevers and inflammations, it has not yet attracted much attention. The phenomenon has been discussed by me in several memoirs, and is treated of in the second part of this work (p. 218). In this place I propose to consider the matter mainly in its practical bearing. Not only shall I be able to show that the increase of bioplasm affords a highly important indication for treatment, but that many different remedies which experience has proved to be of use in febrile

and inflammatory diseases are valuable, on account of the influence they exert in checking the growth of bioplasm and preventing the impending destruction of tissue; and although in too many instances the process may have proceeded beyond our control, yet even in these we may often retard the inevitable result.

In bad cases of fever and general inflammation the patient may die, as already indicated, from failure of a congenitally weak heart; but the life of those who have the advantage of a strong and vigorous organ is often destroyed at a later period of the malady by the excessive growth and multiplication of bioplasm in the blood, one consequence of which is plugging of so many capillary vessels of the tissues as to lead to complete suspension of their action, and to damage or destruction of their structure. If life be preserved, the structure of the capillaries, nerves, and adjacent textures may be irreparably damaged; and in this way parts of organs of the highest importance to life may be so altered, that they can never regain their former healthy condition, in which case the organism will never be sound, or as healthy and vigorous as it was before the attack of fever.

In the tissues of many of those who have died from fever of many different kinds I have seen the capillary vessels and small arteries and veins completely obstructed by minute particles of rapidly growing bioplasm, and in not a few instances the minute vessels are dilated in the interval between two *constricted*

points, which leads me to conclude that the bioplasm had actually increased in amount by growth long after the circulation had completely stopped. The walls of the vessels are much altered, and in some instances the bioplasts are five times as large as in the normal state, and project much into the interior of the vessel, dividing and subdividing freely—or proliferating, as the saying is. I have observed these facts both in man and animals.

So far, therefore, from there being increased activity of the circulation (as inferred from the rapidity of the heart's action) associated with the hot feverish state—as used to be supposed—the latter is characterised by restricted capillary circulation and a tendency to complete obstruction of so many of the capillary vessels that many tissues and organs are seriously deranged, their structure damaged, and in bad cases even death occasioned. Now, it is this tendency to the increase of the bioplasm that he who treats fever must endeavour to avert; and one thing which contributes in a most important degree to effect this end is the maintenance of the force of the heart's action, as has been already pointed out. By promoting free circulation, so as to keep the whole mass of the blood constantly moving, and mingling, and changing, not only is the growth of its bioplasm impeded, but the bioplasm already formed is exposed to oxidation and other changes, which lead to its disintegration, to be soon followed by the removal of the products of its decay. Wherever the circula-

tion flags, the increase of the bioplasm is favoured, and the first abnormal augmentation takes place in those organs, such as the liver, spleen, and lymphatic glands, in which the circulation is slowest in the normal state, and where the bioplasm is renewed according to the very moderate demands of the system in health.* But, besides this advantageous effect, the free action of the circulation renders possible the removal of many noxious materials tending to produce a paralysing or poisonous influence upon the nerves distributed to the capillaries, small arteries, and veins of the skin, urinary organs, and bowels, as well as the nerve-centres with which they are connected, upon the integrity of which the condition of health is absolutely dependent.

Such, then, so far as I have been able to make out, is the interpretation of the phenomena which may lead to the destruction of life, if bad cases of fever are left to pursue their natural course. "Nature," it seems to me, manifests neither a conservative nor reparative action during the course of fever, and death may result long before the period arrives when natural repair becomes possible. But it would be a great mistake to hold that "Nature" is responsible for the development of the feverish state. The natural history of febrile diseases is pretty well known by this time, and as in many cases we are able to anticipate increase of fever-

* From observations I have made, I think it probable that in acute, severe fevers, from ten to twenty times as much bioplasm is produced in a given time as would be formed in the healthy state. Not only is the growth of bioplasm favoured in those morbid states, but destruction of the products of its decay is greatly impeded and retarded.

ishness, we may place the patient in a more favourable condition to withstand it than "Nature" unaided can do, and we may often mitigate the force of a blow that we may be powerless to ward off.

"Expectant Medicine" in severe cases of fever is not justified by the facts known concerning fever, and an expectant attitude will no more save life than it will extinguish fever-poison, effect sanitary improvements, or preserve people in a state of health which will enable them to resist the influence of disease-germs. Expectancy, as a principle, is no more justifiable than is the giving of harmless pilules or coloured water as a practice. In the treatment of real disease, mere passive expectancy means the denial of knowledge, the ignoring of broad facts of observation and experiment, a contempt for the lessons taught by experience, and a disbelief in all that has been handed down to us by those who have observed, and laboured, and thought before we lived.

The Principles by which we should be guided in the Treatment of Slight Cases of Fever and of the Early Stage of Cases which may afterwards become Serious or Desperate.

It would seem almost superfluous to urge that the admission that there are cases of fever which will get well without any medical treatment whatever, and cases that cannot be saved by any mode of treatment yet discovered, does not involve the inference that nothing is to be gained by treat-

ment, and that fever must be left to itself, or the natural course of the disease merely watched with care, and the efforts of nature assisted. But yet, from some of the remarks made of late years, many a student has been led to suppose that it was really doubtful whether the patient suffering from fever was placed in a more favourable condition as regards his chances of recovery if he was subjected to treatment, than if the course of the malady was merely attentively *watched* by his medical attendant. Some, indeed, seem to cast doubt upon the utility of all treatment, and the art of medicine, according to them, would seem to be almost reduced to the art of consoling the sick and their friends.

Scientific doubt concerning the action of remedies, encouraged by general scepticism or disbelief in the remedial influence of measures, many of which were believed in by our predecessors, has paved the way for the reception of that most interesting and highly intellectual form of philosophical credulity, "nihilism." Such a result, however, can hardly be fairly accounted for by the advance of knowledge, as has been erroneously intimated. It seems rather to be due to an obstinate determination on the part of an energetic few to insist that all shall look at things from their own particular point of view; and that only certain facts, which are of importance by reason of having received *their* imprint, are to be regarded as facts at all. On the other hand, all phenomena which

seem to be inconsistent with the predetermined conclusion accepted by this active minority, are to be ignored or denied. But notwithstanding all the advantages resulting from the tendencies of thought at this time, therapeutic nihilism has happily not yet been generally acted upon in this country, nay, it is not always acted upon where it is encouraged as a therapeutical maxim. Practitioners, it is to be hoped, will not soon be brought to admit that between the remedies prescribed by them, and certain results which follow soon after the remedies in question have been introduced into the body, there is no relation—and this, although the same sequence of phenomena is noticed in case after case. Is it an easy matter for anyone to convince himself that a medicine which produces certain quieting effects in health is useless in disease in which restlessness is painfully manifested, although this restlessness may be certainly relieved and without any harm resulting from the administration of the remedy in question? No one will deny, for example, that opium acts upon the system in a special manner, but many talk as if they doubted whether this action of opium was of the slightest advantage, or was desirable, in disease. Nay, they seem to argue that, although opium and other remedies do undoubtedly allay pain, it by no means follows that such drugs are of any advantage, or ought to be given, in certain morbid conditions accompanied by pain, distress, and suffering, notwithstanding these very remedies have been given, and

have been believed to have been of use, by many successive generations of practitioners.

Of all forms of scepticism, therapeutic scepticism is the most extraordinary, seeing that many of the questions upon which doubt is cast are matters of every day experience, and some of them can even be determined by a very simple experiment being made upon the organism of the sceptic himself. As a fact, however, sceptical philosophy is invariably supported by dogmatic teaching of a very decided character, promulgated by authority that cannot err. It is this that enforces conviction and wins disciples.

But surely no one who has studied the phenomena of the body in health and disease will permit himself to be misled either by those who, professing to be able to *cure*, seem to be proud of their ignorance concerning the *nature* of morbid changes, or by those melancholy therapeutic nihilists who profess to base their scepticism upon the inferences arrived at by philosophical speculators who demand acquiescing reverence on the ground that they have devoted themselves to pure science, and have condescended to leave the pursuit of practice to less highly trained intellects.

It is really impossible to discuss the treatment of fever or any other form of disease, as it ought to be discussed, without considering the bearing of many facts which might appear at first sight to be of scientific interest only. It is, therefore, very important that all students should be well educated in science, so that

when they come to be practitioners, they may be ablé to form an opinion upon the views that are put forward, and may be in a position to pursue certain branches of scientific investigation, if opportunity offers, and thus extend our knowledge of the nature and treatment of disease.

Of the Treatment of Slight Fever.—We may learn something concerning the treatment of the feverish state, if we study carefully the changes which go on in our own bodies when we ourselves are suffering from a slight feverish cold, and observe carefully the effects of the remedies we think well to take for the alleviation of the symptoms. The instinct which prompts a patient suffering from the feverish condition to seek warmth, and to prefer plenty of blankets and the neighbourhood of a good fire, to a cold bath or the free application of cold air to the surface, is probably preservative, and experience justifies the adoption of such a course. All the unpleasant feelings experienced by any one who has a feverish cold, disappear for the time if he takes a warm bath. If the skin can be made to act freely, by keeping the surface warm, internal heat is got rid of very quickly, and thus the temperature of the body kept down. Mr. Garrod has proved by experiment that by simply removing the clothes from the healthy body the temperature of the blood rises as much as two degrees of Fahrenheit's scale, while, very soon after the skin has been again protected by a badly conducting artificial

covering, the temperature falls to its normal standard. The explanation is simple. By exposure to cold the radiation of heat from the cutaneous surface is reduced, the vessels are caused to contract, and the blood driven *from* instead of towards the surface of the body. Hence, if we want to cool the blood and internal tissues in ordinary fever, we must keep the skin warm and protect it from currents of air. If, however, the temperature is already very high, indeed near the point at which, if reached, death must soon occur, the decided external application of cold is probably the only way of keeping the patient alive (*see* page 335) ; but we are now discussing the principles of treating slight degrees of fever only. By external warmth, then, the blood is determined to the surface, the glands are excited to act, and by free perspiration the blood is relieved of certain constituents which were accumulating in it, to the detriment of the organism. The tension of the vessels of the secreting organs is lessened, and the removal from the blood of water holding in solution various soluble excrementitious substances soon follows. We all know how pleasant is the sensation produced when moderate perspiration is established in the early stage of a common feverish cold. Even placing the feet in very hot water relieves, in a few minutes, the unpleasant feeling of tension about the head, nostrils, throat, and neck, which, doubtless, we have all experienced. And there is no doubt that in promoting

perspiration by those simple plans known to all, and by the introduction of sudorific remedies, the feverish attack may be shortened, and its intensity lessened. By free perspiration, not only are various materials removed from the blood, but thirst is excited, the gratification of which insures the solution and subsequent elimination of more material which might otherwise be devoted to the abnormal nutrition of bioplasm, leading to those serious consequences which have been already referred to. The moderate perspiration excited by exercise conduces to health in this way, and renders needless the occasional use of the warm bath. If free sweating be artificially induced at the right moment, it is not improbable that a feverish attack may sometimes be altogether averted. Moreover, free excretion from one surface is not unfrequently followed by free action on the part of the other excreting organs, and in this way a quantity of material, the presence of which in the blood would be detrimental, is got rid of before any harm has resulted.

But a slight feverish attack may be *cured* by simple rest and warmth. Very often twelve hours' uninterrupted rest is the only remedy that is required to cut short many an attack of feverishness—indeed, healthy constitutions frequently "sleep off" their feverish ailments, and many children who go to sleep in a highly feverish state, wake up twelve hours afterwards perfectly well.

I have often been led to suppose that a sharp attack

of diarrhœa, occurring during the period of incubation of virulent fever-poison, has mitigated the subsequent attack of fever consequent upon the multiplication in the body of the special fever-germs. This conclusion is supported by the fact, that in many cases all the symptoms of commencing continued fever have suddenly ceased upon the occurrence of free action of the skin, kidneys, and bowels. Of course, no one can say, in any given case, that the symptoms were really due to the actual presence of contagious poison in the blood, which was destroyed or removed in consequence of the rapid outpouring of soluble materials and water; but a number of considerations render it probable that such an inference is really correct—at least in some instances.

In many of those struck down by contagious fever, there has been for some time previously imperfect action of the eliminating organs, during which period the blood was acquiring a state favourable to the growth and multiplication of disease-germs. When the excreting organs do not act properly, certain substances, which ought to be eliminated, get reabsorbed by the blood, and then the composition of the circulating fluid becomes altered, and its properties modified. Nor is it astonishing that excrementitious substances, perhaps modified in character, and circulating freely among the most delicate tissues of the body, should derange their action. Sick headache, certain muscular and nerve pains, aching of the limbs,

and the sensation of general discomfort which pervades every sensitive part of the body (and parts, even, which in health afford us no evidence of their existence), are probably due to the presence of those noxious matters which ought to have been eliminated. Such considerations lead us to a plausible explanation of the influence of methods of treatment, the utility of which has been conclusively proved by experience. Thus, we see how purgatives act beneficially in the early stage of the feverish state; and, of all purgatives, calomel and other mercurial preparations. These promote free action of all the glands which pour their secretions into every part of the alimentary canal, from the mouth to the anus. By this free excretion quantities of peccant substances are removed from the blood, which otherwise would have remained there. Similarly we may explain the beneficial action of diuretics and sudorifics, of a course of German waters, of the frequent use of the warm bath and of the Turkish bath in many forms of disease. Those living in cities, taking little exercise, and imbibing the warm air of rooms, will do wisely if they excite artificially the free action of the skin, kidneys, and bowels, from time to time. In this way, and by care in eating and drinking, they may keep the body in fair health under great disadvantages, and diminish, I believe to a very great extent, their liability to troublesome febrile attacks, to contagious fevers, and to inflammatory disorders.

Indications for Treatment as deduced from a knowledge of the state of the Blood prior to an Attack of Fever.—That the blood is not in a heathy state prior to an attack of fever is proved by many facts, though analyses of the blood during the period of incubation of fever poisons are wanting. The bioplasm is probably in larger proportion than in the healthy state. The minute particles of living matter which I have shown to exist in the blood in vast numbers, and to pass through the walls of the capillaries in certain cases,* probably increase in every feverish condition. But, besides this, the white blood corpuscles and the masses of bioplasm in the walls of the vessels and in the tissues become larger, as was described in my Cattle Plague Report, published in 1866. The increase of the bioplasm in the blood, in the vessels, and in the tissues is preceded by the formation in the blood of pabulum adapted for its nutrition. This soluble nutritive matter would have been converted into excrementitious substances in the normal state, and its accumulation in the blood would have been thus prevented; for, as is well known, in health, excess of food introduced into the body does no harm, because the amount over and above that required for the system is soon converted into excrementitious matters, which are excreted and removed altogether from the body. As an indication that the

* *Transactions of the Microscopical Society*, December 9, 1863, "On the Germinal Matter of the Blood," etc.

blood is changed, I need only advert to the fact that it has been noticed over and over again that slight wounds or abrasions of the skin do not heal when fever poison is circulating in the blood. The bioplasm of the wound grows very fast, and time is not allowed for cicatrisation. Perhaps very minute particles of the bioplasm which multiply in the blood are continually escaping, suspended in the serum through the walls of the capillaries. Unquestionably the capillary circulation is less free than in health, and sometimes this is so marked as to cause a peculiar and characteristic dusky appearance of the skin, which often attracts the attention of friends.

In many instances evidence of derangement of the blood is afforded by the fact of the existence of considerable disturbance in the healthy functions. The appetite is bad, there is giddiness, and perhaps headache, besides which the nervous and muscular systems are so disturbed as to cause a feeling of fatigue and general langour and discomfort. Muscular movements are accompanied by pain and uneasiness, and the patient is disinclined to move about. Very little exercise gives rise to great fatigue, and every movement of inspiration becomes an actual effort. Oftentimes, however, these derangements are not sufficient to attract attention ; and when the fever breaks out the patient appears both to himself and to his friends to have passed almost suddenly from a condition of health into what may become a very serious and

perhaps dangerous fever. Sometimes during the time when the poison is growing and multiplying in the blood, the person is easily fatigued, and only able to perform his usual amount of work by dint of making a great effort; or by an unfortunate coincidence he may have been compelled to work unusually hard, while at the same time, in consequence of his appetite being bad, he has been able to take little sustenance. The severity of the subsequent fever, as well as the danger to life, are much increased by such circumstances and by want of care during the period of incubation. But the feverish symptoms may come on so gradually that the patient himself is hardly aware he is really unwell, although his temperature may be four or five degrees above the normal standard. Some persons have so much courage that they refuse to yield until they are no longer able to move about, and the state of fever is thoroughly established. If, however, the patient rests much during the ante-febrile period, takes beef-tea and a little wine, and makes no effort to conquer the feeling of lassitude he experiences, he will be more likely to pass through the illness favourably, and, if he have a severe attack, battle successfully against it, than if his strength be exhausted before or during the first few days of the feverish state.

There is, however, reason to think that changes have been going on long prior to the development of the fever, and that the body of the victim of fever-

poison has been prepared for the growth and multiplication of disease germs by a long course of preliminary change. I think that the condition favourable to the contraction of fever slowly results from long exposure to circumstances adverse to health. And although an attack of typhoid, for example, may be a direct consequence of exposure to the emanations from filth, it is quite certain that the body and the blood of the person attacked have been seriously deranged by previous exposure to noxious influences, or to circumstances likely to exhaust the energy and depress the health. In some instances we may obtain evidence that for many weeks or months the organism has been unconsciously, but most surely undergoing changes which prepare it for the reception and growth of the poison. It is the development of this state of derangement that we so much desire to interfere with. Could we succeed in preventing the preliminary changes in the blood, or restore that fluid to its healthy condition when it is only slightly deranged, thousands of lives would be saved annually.

Sudorific Remedies, Diuretics, and Purgatives.

Sudorifics and Diuretics.—Under this head I propose to refer very briefly to some of the remedies which I have myself been in the habit of prescribing most frequently. The number of sudorific, diuretic, and purgative drugs is very large, and many of them act in the same manner. Whether, for example,

we employ a citrate or a tartrate probably matters, in the majority of cases, very little ; but the tendency to diarrhœa or to constipation might, in certain instances, influence our choice of one or other of these salts. Of all the saline sudorifics usually prescribed during the feverish state, I believe *liquor ammoniæ acetatis* to be one of the most useful. Some consider it, as well as other alkaline acetates and citrates, to be of little or no value ; but, from experiments tried upon myself, I feel convinced that the solution of acetate of ammonia does good in the feverish condition of body. Many years ago I used to suffer much from quinsy, and I found that when I took plenty of acetate of ammonia, the swollen tonsil soon became less. My experience of its use in others is equally satisfactory. I think that we usually give it in too small doses. Half an ounce every four hours for an adult is not too much, and it may be continued for several days. I think it really acts upon the liver as well as the secreting organs of the skin and upon the kidneys ; but, besides this, I believe it does good by promoting the removal of saline and other constituents from the tissues, and favouring their elimination. The feeling of tension and general discomfort which is experienced at the commencement of an ordinary catarrhal attack is often relieved after two or three doses of liq. ammon. acet. have been taken.

A glass of hot spirits or wine and water, a dose of sulphuric ether and sweet spirits of nitre, or a little

ipecacuanha, a small dose of Dover's powder or of antimonial (James's) powder, have been found to work wonders. Even a tumbler of hot water, or a basin of hot gruel or arrowroot, will relieve the feverish symptoms for a time, by promoting perspiration. Diuretic medicines also enjoy a high reputation for curing feverish attacks; bicarbonate of potash, bitartrate of potash, acetate and citrate of potash, and a number of others are in common use. Nitre (nitrate of potash) dissolved in plenty of water, or added to linseed tea or some herb tea, is a very old, as well as a very useful remedy. If the kidneys are perfectly healthy their free action should be encouraged, as diuresis affords the greatest relief. There are some persons whose sweat-glands act very slightly, and upon whom neither sudorific remedies nor the hot bath exert much influence, but whose kidneys, on the other hand, are easily excited to act most freely, and respond almost immediately to the simplest diuretics —even a glass of water.

Purgatives.—As already mentioned, the opinion that an attack of impending illness has been averted by free diarrhœa is very generally entertained, and is probably correct. It seems possible that in this way substances capable of producing a deleterious effect upon the economy may be removed, and it seems not impossible that in some cases even disease germs may be carried out of the system before the time has arrived for them to produce their characteristic effects,

and it is, at any rate, certain that morbid materials which may have been for some time accumulating in the blood may be in this way directly removed ; and at least, in this respect, the body will be in a more favourable condition to bear an attack of acute disease than would have been the case had such noxious materials still remained in the circulation. Moreover, many of us, after having been exposed to the influence of noxious gases and other deleterious agents, have been seized with symptoms similar to those which often precede a specific feverish malady, but have been completely relieved by a sharp and sudden attack of diarrhœa. These and many other circumstances which I will not stop to recount have been considered by many to justify the old-fashioned practice of giving purgatives at the commencement of an attack of acute illness, or on the occurrence of symptoms which seem to portend an attack. Like other routine practice, this has been rightly condemned ; but nevertheless, I believe it to be thoroughly sound practice in many instances, and I think that of late years patients have been allowed to suffer from great inconvenience and discomfort for many days, when a simple purge might have produced immediate relief. To purge freely just as an attack of enteric fever is coming on would unquestionably be very wrong ; but, on the other hand, what relief is sometimes afforded by the administration of a sharp purge in many a case in which we have reason to think pneumonia, or

bronchitis, or pleurisy, or acute rheumatism is about to supervene!

I have more than once seen acute surgical fever, in which the temperature was 104°, following an operation, suddenly cut short by a dose of calomel; and even in cases in which the symptoms were such as to justify the inference that inflammation of the membranes of the brain was commencing, two or three good doses of calomel have apparently been the means of effecting a cure. Nor can I believe that the practice of giving sharp purgatives, so frequently adopted by the late Dr. Chambers, rested upon an altogether erroneous view, and was entirely superfluous and useless. I doubt if the old woman's detestable dose of warm salts and senna, administered with never-failing regularity once a month to each unfortunate little schoolboy of former days, was by any means an unwise or even an unscientific proceeding. I am not at all sure that many an organism which becomes the victim of disease-germs would not have been able to resist the contagion had the excreting organs been judiciously excited to moderate action at the proper intervals of time. It is probable that the occasional free action of the bowels, skin, and kidneys greatly diminishes the chance of contracting disease. Salts, senna, jalap, scammony, and cream of tartar are remedies very often used, in one form or another, by people who are their own medical advisers, and who work hard; and many of those who waste enormous

quantities of meat and beer, upon the false notion that these are required to give them the necessary strength, discover, as they get older, that a good purge every now and then affords the greatest relief, and they not infrequently communicate to others their own experience.

The various purgative saline waters—Carlsbad, Freiderichshall, Pullna, etc.—and purgative salts, such as Seidlitz powders, salts of magnesia, soda, etc.—are largely taken by the classes who are not dependent for their livelihood upon muscular exertion, and who take far more nutriment than their system requires. It seems to me quite in accordance with reason to conclude that, where the excreting organs of the alimentary canal habitually act imperfectly, not only will great benefit result from the judicious use of certain purgative remedies, but that the blood may be preserved in such a state as to render the changes which occur in fever improbable, if not impossible.

Upon careful inquiry of those who are the subjects of feverish attacks, it will not infrequently be found that the health has been slightly deranged for some time previously; and, among the many slight or trivial symptoms experienced, there is almost always evidence of imperfect and irregular action of the alimentary canal, and of the many important excreting glands connected therewith.

Who can suppose that the very imperfect action of the large bowel so frequently experienced by those who

live in cities can conduce to the healthy condition of the tissues? Excrementitious materials which should be entirely removed get reabsorbed into the circulation, and, though no doubt changed and perhaps excreted from other surfaces in a different state, cannot fail to derange, at least to some extent, the delicate action of the nervous and muscular tissues. The detestable odour of the breath so disagreeable both to the patient himself and his friends, and more rarely the strong-smelling matters secreted by the sebaceous glands of the skin, are due to this cause in some instances; indeed the experience of every practitioner must afford many convincing proofs of the correctness of this reasoning; the patients themselves are well aware of the great benefit which results from an occasional free action of the bowels, and, indeed, not a few have discovered by experiment that in order to keep themselves in health it is necessary to take at certain intervals a dose of purgative medicine. Of all purgatives, mercurial preparations are of the greatest use in these cases. Purgative treatment is by no means necessary for all persons, but it is unquestionably advantageous to many. Not a few working men have not only discovered that an occasional purge is necessary to keep themselves in a state fit for work, but they have found out by experiment the particular kind of purgative which produces the best effect. Those who have of late years been loud in their condemnation of the use of mercury are perhaps not aware that

the much-maligned calomel enters into the composition of most of the purgatives which enjoy the highest repute amongst labourers and artisans, as well as the powders which the mothers of families in every part of England have found to be most beneficial in the treatment of many of the ailments from which their children from time to time suffer. Podophyllin is also a valuable purgative, but somewhat uncertain in its effects. It should be given in doses of not more than one-third of a grain with colocynth, rhubarb, or some other purgative. It should be distinctly borne in mind that the object of giving a purgative is not merely to unload the large bowel, for purgatives are often eminently useful in cases in which there is certainly no fæcal accumulation. As has been already intimated, by purgation fluid is rapidly removed from the blood, and with the fluid so passing away many other things, the presence of which is deleterious, escape.

The different classes of remedies, the action of which has been referred to, effect a change in the composition of the blood. Diuretics, sudorifics, and purgatives promote the removal from the circulating fluid of substances which accumulate in it, and which are calculated to disturb healthy action if they are not got rid of. No doubt, in perfect health, the exercise taken, the fluid drank, and certain materials taken in the food, promote the action of these emunctories sufficiently; but the artificial conditions, especially as

regards insufficient air and exercise, under which most of us have to live, necessitate attention to these points. By all the remedies above referred to the removal from the blood of fluid holding in solution various substances is insured. Neither perspiration, nor diuresis, nor purgation can occur without the escape of much watery fluid. By the removal of this fluid, thirst is excited, and a demand for the introduction of more fluid—which, in its turn, is got rid of—soon follows. In this way various soluble and some imperfectly soluble substances which had accumulated in the blood in undue proportion are gradually removed, and the feverish condition may cease. In other words, the healthy state may be restored by the use of appropriate remedies in efficient doses. The *illness* consists of the non-removal of these substances and their gradual accumulation, until the normal action of many tissues, and particularly that of muscle and nerve, is disturbed. In slight cases a similar result is obtained by rest and by withholding food for four-and-twenty hours, and the *cure* (!) of the feverish condition is brought about as effectually as by the administration of remedies, though perhaps less pleasantly, and oftentimes more slowly.

The Administration of Liquids, Food, and Stimulants in the Febrile State.

Liquid.—During the feverish state there is usually much thirst, and patients crave for drink. Con-

siderable quantities of fluid may be taken with apparent advantage, and, at least in the majority of cases, the yielding to the desire for cool liquids seems to do no harm. I have known many patients take more than twelve pints of fluid in the twenty-four hours. Broth is probably of use in fever, mainly on account of the water it contains, and the same remark is applicable to much of the beef-tea that is given, as well as to the diluents in favour. In cases, however, in which the stomach is distended and the abdomen tympanitic, the physician should not permit a very large amount of fluid to be swallowed. Sometimes, even when taken in very small quantities, the fluid is not absorbed, and by accumulating in the bowels stretches their coats, and thus paralysis of their peristaltic action may be occasioned. I have known a strong man destroyed in the course of twenty-four hours in consequence of paralysis of the muscular coat of the intestine, the cavity of which was found after death to be enormously distended with liquid.

In dieting a fever patient the actual quantity of fluid which is to be given should always be carefully stated. From two to four ounces an hour is a good allowance, and more than sufficient in most cases; but this proportion is often greatly exceeded, particularly in hospital practice—many a patient during the twenty-four hours taking as much as two pints of milk, about the same quantity of beef-tea, besides water almost *ad libitum.* And in the majority of

cases, this free swallowing of liquid does not seem to be disadvantageous. The liquid is absorbed as fast as it is introduced, and the greater part soon escapes from the blood as perspiration ; some, however, passes off in the breath, and a considerable proportion is excreted by the kidneys—the activity of these organs often increasing considerably after the first few days in cases where the malady runs a short and favourable course.

In all forms of fever it is important to prevent the patient from drinking considerable draughts of cold water, milk, or other fluid ; but small quantities even of ice-cold water given at intervals of half-an-hour or more do no harm, and are extremely grateful to the patient. By the frequent introduction of small proportions of fluid (one or two teaspoonfuls) the blood is diluted, the solution of the noxious materials formed during the feverish state is effected, and the removal of these by the skin and kidneys promoted.

Food to be given during Fever.—Although in the feverish condition, by the free action of the secreting organs, the state of the blood may be much improved, and the nutrient fluid rendered more fit to traverse the vessels, it must be obvious that, unless new materials be introduced to compensate for those removed, the nutritive powers of the blood will fail, and the patient may die from sheer exhaustion. Hence it is very necessary to consider how food may be given without causing derangement of the digestive organs,

and what kind of nutritious matter is most suitable under the circumstances.

It is of great importance that the nutritious matters given in fever should be such as will not only be readily absorbed, but quickly assimilated—matters capable of being taken up and applied to nutritive purposes without undergoing those slow preliminary changes which are requisite to convert the less soluble constituents of ordinary-health diet into a fit state for nourishing the tissues. In fever the solvent secretions are not only very scanty, but their properties are altered. The saliva, the gastric juice, the bile, and the pancreatic fluids are all defective, and the organs which secrete these important solutions, as well as the numerous glands in every part of the digestive tract, are seriously affected, and their action impaired. For these reasons, great care should be taken in the selection of the food, and the utmost precaution exercised in preventing the patient from having any particles not likely to be readily digested, or anything that has commenced to undergo the slightest putrefactive change. In hot weather the nurse should be particularly observant on the latter point, for the most digestible foods very soon undergo decomposition, and sometimes good beef-tea will be tainted in a single night. For this reason it is important not to use the patient's sick-room as a larder, the air of which, irrespective of its temperature, is prone to hasten putrefactive decomposition, and is no doubt

loaded with fungi and germs of bacteria ready to multiply.

As I have already suggested, in the slightly feverish condition, the treatment of which is now under consideration, little food is really required. Mutton broth, weak beef tea, camomile tea, and infusion of many herbs (some of which are undoubtedly nauseous enough) have been very strongly recommended for their curative properties; but their efficacy is mainly dependent upon the quantity of water they contain, as has been already mentioned. But, on the other hand, the physician must never forget, that in many very bad cases of fever in which nutrient matter is much required, little can be taken, and life may be thereby endangered. The patient not unfrequently rebels against every kind of food, and if any be swallowed, distressing vomiting is immediately excited, or the food accumulates in and distends the stomach, doing harm in many ways. Under these circumstances, we have in some cases to feed the patient by enemata, while in others we may rely for a time almost entirely upon stimulants of some form or other, until the state of the stomach improves. But it will be more convenient to consider the question of giving stimulants in low feverish conditions, under the head of alcoholic treatment. *See* page 381.

Occasionally every kind of food is spat out forcibly as soon as it is taken into the mouth, and unless the nurse displays good judgment and care, this rejection

becomes a habit, and in very bad cases is continually repeated, while the patient remains in a half delirious or even totally unconscious state. When this troublesome symptom is first noticed, it is better to change the food. Milk alone may be offered, or iced milk, or even pure water only, for a time given.

Whenever it can be obtained, well-made beef-tea, made from fresh beef, should be tried. The "essence of beef" (sold by Brand and Co., Little Stanhope-street, Hertford-street, Mayfair) is a most valuable preparation, and almost always liked by patients. It may always be obtained quite fresh, and can be forwarded daily into the country. This most excellent preparation for invalids should not be kept more than three days in winter, or two in summer. Next to these freshly made essences may be mentioned the extracts of meat which are now largely sold. During the last few years Liebig's extract has much improved in quality; and the meat extracts made by Messrs. Whitehead are extremely good. A very palatable form of beef-tea is made by merely adding boiling water to two teaspoonfuls of Liebig's extract, placed in a teacup. In some cases it is necessary that whatever is given should contain very little salt; for, in consequence of numerous cracks upon the tongue, and the presence of little superficial sores on different parts of the mucous membrane of the mouth, this substance causes great pain, and sets the patient against food. The fresh beef-tea and Brand's essence

contain much less salt than the inspissated extracts. Some forms of solid beef-tea also are made without any salt being added.

In the treatment of all febrile diseases we must never lose sight of the fact that the action of the stomach, like that of other organs of the body, is much deranged. Should the stomach be irritable, ice, a little dilute hydrocyanic acid and soda, and other remedies may be tried. Although in slight cases there is usually no harm in yielding to the patient's disinclination to take food, this must certainly not be permitted during the early period of any of those febrile diseases which we know will probably last for many days; and even in the mildest attacks the convalescence is often much reduced in duration if only the patient can be fed during the whole period of the malady. In long and severe cases the regular introduction of small quantities of nutritious, easily digestible food at short intervals of time, is most important. At the least two or three tablespoonfuls of good, strong, beef-tea or milk should be given every two, three, or four hours, or one tablespoonful at much shorter intervals if the case is a bad one. If we try the experiment of treating an ordinary cold, when there is complete loss of appetite, with good beef-tea or soups, with a little wine administered every three or four hours, and then on another occasion try the starving process, we shall be able to decide, by studying the effects upon our own organisms, which plan

is the most efficacious. In very slight cases of fever, only a moderate quantity of food is required The brod-suppe and butter-suppe of the Germans may be given, and the patient will do perfectly well. In fact, the principle of treatment often adopted in such slight cases is that of giving diluents ; for weak beef-tea, &c., consist almost entirely of water, and it would be absurd to suppose that the very small quantity of solid matter contained therein really compensates for the material removed from the body by the secreting organs. We know, indeed, that it does not, and that the patient loses weight, and loses weight fast. In a short time the feverish state passes off; the secreting organs begin to act again freely ; the salivary glands and the stomach resume their function; healthy secretions are produced in considerable quantity ; the nutrient constituents of the food are freely dissolved ; and the loss of tissue which had occurred during the feverish period of the malady is speedily repaired, and not unfrequently more than repaired—for it is not unusual to find that for some time after a patient has recovered from a feverish attack, he improves in health, and becomes stronger and more robust and vigorous than he had been at any antecedent period of life.

Milk is one of the most valuable forms of food, not only in cases of low fever, but in almost all forms of disease. Sometimes it is desirable to dilute the milk with an equal quantity of water. If there should be

nausea or sickness it may be iced, and a few drops of hydrocyanic acid may be added. If a little *lime-water* or a few drops of *liquor potassæ* be mixed with milk it will often be retained, even though the stomach be in a very irritable state. There is no objection to mixing ammonia and other medicines with the milk, and any wine or brandy to be given may be added to it. In the case of sick children, milk is by far the best article of diet, and oftentimes the only one which can be successfully used as a vehicle for the administration of medicine.

During the last few years we have had the advantage of being able to employ the concentrated Swiss milk, which, when properly diluted, is a most pleasant drink, and perhaps less liable to cause sickness than ordinary fresh milk. In some cases, however, milk is altogether refused. Whey, from which the curd has been separated, may be tried; but if this does not suit, we must depend upon simple nutritious soups, eggs cooked in various ways, beef-tea and the extracts of meat already referred to.

The Use of Pepsin.

The digestion of milk and all animal soups is promoted by putting into each cupful three or four grains of pepsin. If a mixture of beef-tea and pepsin be allowed to stand in front of the fire for a couple of hours, artificial digestion will have commenced, and if for a somewhat longer time, it may have been com-

pleted, and the fluid will be in a state favourable for absorption, the weakened digestive power of the stomach not being taxed in any way whatever. The solvent action of the pepsin is much increased by the addition of from ten to twenty drops of dilute hydrochloric acid. The casein, which in the case of milk may remain undissolved, may be strained off with some of the oily matter. Phosphoric acid or lactic acid may be also employed; but these act less powerfully.

For many years past I have been in the habit of adding *pepsin and hydrochloric acid* to the beef-tea that is given in very bad cases of fever, and I am sure with the greatest advantage. The stomach is relieved, and a comparatively large amount of nutrient matter digested and absorbed within a given time. By this plan the tympanitic state of abdomen, which is sometimes so distressing, is relieved in the course of a few hours, and its recurrence prevented during the illness.

The pepsin used for this purpose, and generally employed by me in medicine, is prepared according to the plan I devised more than fifteen years ago; and as the process is but little known, although simple, it will, I think, be practically useful to give an account of it in this place.

On the Preparation of Pure Digestive Powder or Pepsin from the Pig's Stomach.—Various chemical processes more or less complicated have been employed in the preparation of pepsin. Partly in consequence of these being tedious and difficult of

performance, and the results uncertain, and partly from the sale of perfectly useless preparations, the remedy has to some extent lost its reputation. Many years ago (1854) when engaged upon some experiments on artificial digestion, and after having met with considerable difficulty in obtaining clear solutions that would filter, I tried various new plans of preparing digestive fluids ; and from the circumstance that the pig was an omnivorous animal, with a very strong digestion, and his stomach to be easily procured for a small sum, I was led to try his pepsin in preference to that of any other animal. The following mode of preparation was found to answer very satisfactorily. It is free from many of the objections to which other processes are liable.

The mucous membrane of a *perfectly fresh* pig's stomach was carefully dissected from the muscular coat, and placed on a flat board. It was then lightly cleansed with a sponge and a little water, and much of the mucus, remains of food, etc., carefully removed. With the back of a knife, or with an ivory paper-knife, the surface was scraped very hard, in order that the glands might be squeezed and their contents pressed out. The viscid mucus thus obtained contains the pure gastric juice with much epithelium from the glands and surface of the mucous membrane. It is to be spread out upon a piece of glass, so as to form a very thin layer, which is to be dried at a temperature of 100° over hot water, or in vacuo over sulphuric acid.

Care must be taken that the temperature does not rise much above 100°, because the action of the solvent would be completely destroyed. When dry the mucus is scraped from the glass, powdered in a mortar, and transferred to a well-stoppered bottle. With this powder a good digestive fluid may be made as follows :—

Of the powder	5 grains.
Strong hydrochloric acid ...	18 drops.
Water	6 ounces.

Macerate, at a temperature of 100° for an hour. The mixture may be filtered easily, and forms a perfectly clear solution very convenient for experiments.

Pepsin as a Medicine.—If the powder is to be taken as a medicine, from two to five grains may be given for a dose, a little diluted hydrochloric acid in water being taken at the same time. The pepsin powder may be mixed with the salt at a meal. It is devoid of smell, and has only a slightly salt taste. It undergoes no change if kept perfectly dry, and contains the active principle of the gastric juice almost unaltered.

The method of preparing this pepsin was communicated by me to Mr. Bullock, of the firm of Messrs. Bullock and Reynolds, 3, Hanover-street, Hanover-square, who at once adopted it for the preparation of medicinal pepsin, and soon improved upon it in some particulars.* Gradually the usefulness of this pre-

* Mr. Bullock supplies genuine pepsin at the rate of 2*s.* per drachm. The dose is from 2 to 4 or 5 grains. *Test:* Less than one grain of this

paration of pepsin of the pig was found out, and it had to be prepared in increasing quantities. I should be afraid to say how many pigs' stomachs have been used of late years during the winter season.

In 1857, Dr. Pavy carefully examined the pepsin prepared and sold by many different firms, and found that this dried mucus of the pig's stomach was the most active of them all (*Medical Times and Gazette*, 1857, vol. i., p. 336). In 1863, Professor Tuson instituted a still more careful comparative examination, and with a similar result (*Lancet*, August 13, 1870); for he found that this preparation *was twenty-five times stronger than some others that he obtained for examination.*

I have purposely abstained from writing about the value of this preparation since the note I first published concerning it in *The Archives of Medicine* in 1856. It has, however, been used largely by many practitioners ever since, who are thoroughly convinced of its usefulness. I have often given it to patients,

pepsin, with ten drops dilute hydrochloric acid and an ounce of distilled water, dissolve 100 grains of hard-boiled white of egg in from twelve to twenty-four hours. In the body probably twice this quantity of white of egg or even more would be dissolved in a comparatively short space of time. The digestive powder prepared from the pig's stomach retains its activity for any length of time if kept dry. I had some which had been kept in a bottle for upwards of five years, and still retained its active power unimpaired. The solution made with this pepsin and hydrochloric acid was nearly tasteless and inodorous. One pig's stomach, which costs 6*d.*, will yield about forty-five grains of the powder prepared as above described.

who did not know what they were taking, but were quite satisfied that improvement resulted ; and I have tested its usefulness in many different ways. It is often extremely valuable in treating the diseases of young children, and I believe that persons greatly advanced in age may sometimes be kept alive by it.

The Administration of Stimulants.

Alcohol.—The mode of action of alcohol upon the organism during the febrile state is very complex, and before discussing the nature of the modifications in the pathological changes probably effected by it, it is necessary to refer to the great distinction between the two objects for which wine and other stimulants are given during illness. Alcohol is prescribed—1. For the purpose of promoting digestion, improving the appetite, and relieving unpleasant sensations about the stomach ; and 2. With the view of directly influencing those most active and serious abnormal changes which are taking place in the blood and in the tissues in all bad forms of fever, which, if they progress beyond a certain degree, must necessarily lead to a fatal result.

I propose to defer the consideration of this latter part of the subject until the action of alcohol in moderate doses in the healthy state and in cases of slight fever has been discussed. The forms in which this substance is taken are very numerous, and nothing is more remarkable than the capriciousness exhibited

by different stomachs as regards the reception of alcohol. Some persons like, and can take without suffering, any form of alcohol. With others beer and malt liquors agree well—better than wine or spirits. A certain number can even take porter, but not ale, or *vice versâ.* With some dry sherry is the only wine that will agree. Port wine suits others; while not a few prefer, or can only take without suffering from derangement of the digestive organs, certain hocks or clarets, or perry or cider. Brandy or whisky diluted will often agree when every other kind of alcoholic drink fails; but even pure rectified spirit properly diluted will not always be absorbed by the stomach without exciting discomfort and favouring the development of unpleasant gases, with certain organic acids, among which butyric, acetic, and valerianic are found.

No one has yet been able to give any satisfactory explanation of the fact that a little wine will occasion in some stomachs the greatest disturbance. Within a few minutes, not only is the process of digestion stopped, but there is pain, and an unpleasant feeling of nausea, not unfrequently accompanied by an actual desire to vomit. In other persons a glass of wine will occasion no inconvenience at the time, but may lead, in the course of from twelve to twenty-four hours, to the development of that unpleasant collection of symptoms which constitutes what is often termed a "bilious attack." Vomiting, purgation, and free diuresis afford relief; but sometimes the disturbance

lasts for days, and is not allayed until the stomach has had twenty-four hours' complete rest from work, or until free action of the alimentary canal and all the glands that pour their secretions into it has been promoted by a dose of mercury. It is, after all, not improbable that this most unpleasant action of alcohol indicates a highly sensitive but not unhealthy action of the nerves of the stomach, and that tolerance of wine and spirits is due to a change which has been induced in the finest nerve fibres—in consequence of which their sensitiveness has been impaired. The tolerance of opium, tobacco, and some other poisons is probably to be explained in the same manner. Nor is tissue change limited to the nerves of the stomach; for it is an unquestionable fact that many of those persons who habitually subject their tissues to the influence of alcohol and tobacco, or both, at an early age, soon exhibit distinct signs of change in many tissues of the body. They look older; and, indeed, physiologically speaking, their tissues are considerably older, and have deteriorated in a much greater degree, than would have been the case if they had not been exposed to the action of the substances in question.

It is very remarkable how great a difference, as regards the capacity for the assimilation of alcohol, is observed in the same person when in ordinary good health, and when suffering from even a slight cold. I have observed this many times in my own case. When in health a very small quantity of wine will disagree,

and not unfrequently give rise to serious disturbance of digestion ; but when one feels depressed and miserable from a feverish cold, three or four glasses of wine may be taken within a very short time with benefit, and with a feeling of immediate relief. Persons accustomed to alcohol in one form may take with advantage some other alcoholic fluid during illness.

If at the outset we have any reason to apprehend that an attack of fever is going to be severe, it is very desirable to administer small quantities of alcohol early in the disease. In this way the stomach may be accustomed to the remedy ; whereas, if its use is postponed until the patient is very ill, and alcohol required in very large doses, the stomach is often in so highly irritable a state as to reject it. The patient's life may be in jeopardy from this circumstance, or fatal exhaustion alone may actually destroy him.

Of giving Alcohol to Young Persons.—My conclusions as regards giving alcohol to the young are in the main not at variance with the opinions of those who advocate extreme temperance. My own experience leads me to believe that the majority of young healthy people would do well without alcohol ; and I believe the habitual daily consumption by young persons—even of a moderate quantity—of wine or beer, is quite unnecessary, and mere waste, while in some instances it is positively injurious to health. At the same time there can be no doubt that in certain cases where the health fails in children, and

even in infants, great benefit results from giving small quantities of wine daily for a short time. Hard-working people, students, professional men, and people actively engaged, have been advised to take stimulants as a general rule—and some, no doubt, require them ; but I believe many would enjoy very good health without any alcohol at all, while the recommendation that they should take plenty of claret or other light wine, is bad advice for several reasons. Not only is light wine not required, but in many cases it deranges the health. That people who can get it will often take a bottle of light wine, and more, is quite certain ; but that they require it, or that it is good for their health, is another matter altogether.

Up to the age of 40 very little stimulant is, as a general rule, really desirable for healthy persons, and I expect most people of average health would get on better without any. My own personal experience is this :—I was never very strong, though always able to get through a very considerable amount of physical exertion without suffering from fatigue. Up to the age of 40 I hardly ever touched stimulants of any kind, and when I did take a little, I not unfrequently experienced an attack of sick headache before my ordinary condition of health was restored. Lately, however, I have found the advantage of half a tumbler of ale daily ; and I can bear half an ounce, and sometimes three or four ounces, of wine without suffering. I dare say, as I grow older, I may, like most persons,

require a little more; but when in the country, and taking plenty of exercise, I feel very well and contented without any stimulants whatever. The experience of some members of my family who have lived to be old, and that of many persons of whom I have inquired, accords with my own. In old age, I believe, stimulants are really necessary, and sometimes are even more important than food itself. I feel sure the life of many old people is prolonged by the judicious use of alcohol, and I think that some who have been very careful all through life, take far too little stimulant when they grow old.

Of the Probable Action of Alcohol in the Body.

But we may now very briefly consider the influence of alcohol upon the organism, and its probable operation as an article of diet. What becomes of alcohol when it is taken into the stomach? There is no doubt that if the spirit is strong when introduced, it is much diluted by the pouring out of fluid from the vessels and glands of the stomach, and that it is quickly absorbed, in its diluted state, into the blood. That this is so is proved by the familiar fact that the smell of alcohol is often very perceptible in the breath. Moreover, as is well known, alcohol has been detected by chemical tests in the breath, in the sweat, in the urine, and in the other secretions, by a number of observers. Alcohol has also been proved to exist

in the blood. There is, therefore, no doubt that alcohol, as alcohol, may not only be taken up by the blood, but may circulate with the nutrient fluid, and eventually pass away from it unchanged. But it must not therefore be concluded, that *all the alcohol every person takes* is thus absorbed as alcohol, caused to circulate through the body as alcohol, and at last excreted unchanged; for such a conclusion would be opposed to the facts of observation and experiment. The truth seems to be, that some of the alcohol taken is unchanged in the system, but that a considerable and very varying proportion of the total quantity introduced is caused to disappear altogether as alcohol, and to pass through most important changes, escaping at last from the organism probably as carbonic acid and water.

A certain quantity of alcohol is *digested* and *assimilated;* and it is quite certain that the capacity for the digestion of alcohol varies very remarkably in different individuals. It is most probable that the alcohol is taken up by, and carried with, the portal blood to the liver. Much of it is then appropriated with other substances by the bioplasm of the hepatic cells, and completely changed. Its elements are re-arranged, and added to the constituents which form the liver-cell, and which gradually break up to form the ingredients of bile, the liver sugar, and the so-called amyloid matter.

It is the living matter of the yeast-cell that splits

up to form alcohol and carbonic acid, water, and a form of cellulose. We shall not be surprised to find that another form of living matter—that of the liver-cell—has the power of appropriating alcohol, re-arranging its elements, and causing them to combine with other elements to form compounds, having properties very different from those of the materials out of which they were made. And it seems probable that under certain circumstances other forms of bioplasm of the body are able to take up and appropriate alcohol ; for it is certain that in some prolonged cases of exhausting disease a large amount of alcohol is readily assimilated, while ordinary foods can only be taken in such infinitesimal amount that we cannot attribute to them much influence in the maintenance of life. In severe cases of fever, as I shall again have occasion to state,[1] the greater proportion of the alcohol introduced is probably not oxidised, as used to be supposed, but appropriated. Its effect is to lower, not to elevate, the temperature ; and, so far from increasing the dyspnœa in bad cases of bronchitis, pneumonia, &c., by throwing increased work upon the lungs, as used to be affirmed, it has a directly contrary effect.

Dr. Parkes has shown that diluted alcohol, given daily in such proportions that not more than two ounces of absolute alcohol are consumed in the twenty-four hours, in most cases improves the appetite, and slightly quickens the heart's action ; but that

larger amounts have an opposite effect as regards the appetite, and greatly increase the cardiac beats.

Anstie and Dupré showed that if doses of alcohol sufficiently large to produce narcotic effects are taken, alcohol escapes in the secretions, but when taken in smaller quantities it is not to be detected. This may be the true explanation of the fact that alcohol in certain cases cannot be detected in any of the secretions at all. It is certain that the quantity required to produce narcosis varies greatly in different individuals, and perhaps this may account for the different results obtained in the course of experiment.

Dr. Dupré has quite recently proved that, of the alcohol taken in moderate doses (48 to 68 grammes of absolute alcohol), only a minute fraction is excreted as alcohol, while by far the larger proportion is disposed of in the system in some other manner.* Dupré's observations show that this alcohol is not stored up in the system as alcohol, and slowly evolved in the form of alcohol. He remarks that the amount of alcohol eliminated per day does not increase with the continuance of the alcohol diet, and that therefore, all the alcohol taken daily must be disposed of daily, and converted into some other substance in the system.†

We must, therefore, conclude that, of the alcohol

* *Proceedings of the Royal Society*, January 25, 1872.

† Dr. Dupré has discovered in the urine and in the breath a substance, which, though not alcohol, gives the ordinary reactions relied upon for detecting that substance. It yields acetic acid by oxidation, and gives

taken, only a small but very variable amount is excreted as alcohol, but that the larger proportion, at least in the case of most organisms, is changed in the system; not simply acted upon by other things in a state of change, as may be effected out of the body, but actually taken up by the living matter or bioplasm, and appropriated. Though probably not applied to the nutrition of tissues, its elements may perhaps be re-arranged by the bioplasm of the liver-cells to form some of the constituents of bile, sugar, fatty and amyloid matters, and by other forms of bioplasm the alcohol may be converted into other substances.

Of the Action of Stimulants in Severe Cases of Febrile and Inflammatory Diseases, and of the Principles upon which their Administration is Based.

The general principles which should influence us in conducting the treatment of fever have been discussed at some length. Although probably every practitioner will admit that some cases of febrile disease will make a good recovery without being subjected to any medical treatment whatever, few will be disposed to deny that even in the mildest attack, judicious medical care is of advantage to the patient. And

the emerald-green reaction with bichromate of potassium and strong sulphuric acid. It yields iodoform. This body was found after six weeks' total abstinence from alcohol, and was detected in the case of a teetotaller.

while it is of the utmost importance for the proper management of the case that we should learn as soon as possible whether it is likely to become severe, it is clear that only the well-informed practitioner, who has watched the patient from day to day, will be able to form a correct judgment concerning so important a matter. In slight cases of fever it is not necessary to prescribe any form of alcohol, but as has been already intimated, in severe cases it is sometimes desirable to give a considerable quantity of stimulant, and there is good reason for the conclusion that in some instances life has been saved by the administration of very large quantities of brandy or whiskey. It has been found that persons suffering from fever will bear alcohol without any narcotic intoxicating effect whatever being induced. It has been demonstrated that a large amount (upwards of twenty ounces of French brandy in twenty-four hours) does not cause delirium in fever patients, does not produce inflammation of the brain, nor increase bronchitis or pneumonia if present. Neither does the alcohol augment dyspnœa even when very urgent. On the other hand it is a fact that patients suffering from fever complicated with severe and extensive inflammation of internal organs, lungs, pleura, pericardium, —have progressed favourably towards convalescence while taking brandy at the rate of more than twenty ounces in the twenty-four hours.

Nevertheless there still continues much difference

of opinion concerning the propriety of prescribing, the utility, and mode of action of this important agent, in severe forms of disease; and although there are few hospital physicians who would treat desperate cases of fever absolutely without alcohol, there are many who give only a few glasses of wine to patients for whom some of us would not hesitate to prescribe much larger quantities of stronger stimulants, because we have learnt that by this means the period of convalescence is shortened, and the patient makes a better recovery.

Considering the grave importance of this practical question, it seems to me desirable that it should be fully discussed, and at the risk of being considered tedious, I propose to pass in review some of the facts and observations which, as I pointed out long ago, justify the administration of alcohol, and enable us to form some notion concerning the precise manner in which this substance acts advantageously in some cases of fever. In this way I hope to be able to support and explain the favourable results of clinical experience. Of the scientific arguments many are based upon minute observations of my own extending over many years, and which were carried out without reference to the question at issue, and indeed without the thought that they might at some future time assist in elucidating it.

Objections to the Administration of Alcohol in Inflammation.—It is interesting, if in some respects painful and depressing, to study the wonderful alterations

which have taken place in our views concerning the nature and treatment of important general pathological changes. The process called *inflammation* lies at the root of many of the disorders—acute and chronic—from which civilized man and the higher animals suffer. Inflammatory action is, as it were, the point round which medical theories revolve, and differences regarding the nature of the phenomena comprised under inflammation have led to divisions upon the most important questions of practice, and have caused the greatest differences of opinion regarding the proper treatment of disease. Inflammation is a subject which always excites intense interest, and even now the nature of the changes taking place cannot be discussed without much feeling. The calm necessary for the steady prosecution of scientific discovery is not unfrequently disturbed by the vehemence and warmth of debate as to the proper interpretation of observed facts.

The term "inflammation" involves increased action; and in all inflammations it is true that there is increased action. In order to combat this undue action and reduce the burning activity of the inflammation, we used to be taught to give remedies which depressed the heart's action and reduced the patient's strength. But it has long been observed that many forms of inflammation are only seen in systems already reduced and exhausted by disease, misery or privation. There are many cases in which frequency of pulse, violent delirium, extreme prostration, and all those

symptoms known to accompany extensive inflammatory action, are associated with a general state of the system which can hardly be made lower than it is without great risk to life. Nevertheless, with such confidence was the truth of the old combustion theory of inflammation believed in and taught, that the efforts to quench the fire or to moderate its intensity so absorbed the attention of the physician, that there was danger of losing the patient ere efforts employed to check the disease could prove successful.

Oftentimes in medicine and in science have facts been explained by theories which had never been deduced from the results of experiment; and when new facts opposed to a theory had been demonstrated, men have sometimes said the facts could not be true, and have persisted in acting upon the theory; at the same time appealing to the dogmas upon which the theory was based to confirm them in the action which, it is to be feared, they had already determined to take. In days long gone by, stimulants had from time to time been given by intelligent doctors, in low conditions of the system, accompanied by local inflammations; and in many cases when the patient felt better after taking wine, practitioners in olden time have even allowed a repetition of the practice, although they felt conscious it was against what were regarded by them as sound principles of treatment which they dared not doubt. The favourable action was ingeniously explained by the discovery of some

idiosyncracy or peculiarity in the constitution of the individual patient, instead of being attributed to changes consequent upon the action of the stimulant upon the phenomena of a particular abnormal state.

Change in Practice.—By degrees, however, it came to be observed that stimulants seemed to act favourably in very many cases in which their administration was quite opposed to theory, and was in direct antagonism with the doctrines then taught ; and at last it was admitted that experience was to be trusted, and that the doctrines formerly taught could not be true in all cases. Still more recently scientific observation and experiment have demonstrated that facts which had been appealed to had been misinterpreted and misunderstood, and that a plan of treatment at variance with the one formerly popular, and in harmony with that now followed out was really indicated. No one who knows what changes are taking place in fever or inflammation, would say that he objects to the exhibition of stimulants, *because* some kind of inflammation or local fever is present. In fevers, which are in reality but general inflammations, the pulse has been observed by hundreds of practitioners to diminish in frequency, delirium to give place to calm consciousness, and the feverish state cease while the patient is taking stimulants. Forty years ago such conditions would have been treated by bleeding, calomel, antimony, and lowering remedies.

Dr. Graves, of Dublin, who, like Todd, had been a

teacher of physiology, advocated as long ago as 1833, support in the treatment of fever; and a stimulating system had been carried into practice by Dr. Blakiston, during the epidemic of influenza, at Birmingham, about the year 1837 (*Clinical Observations on Diseases of the Heart, &c.*, p. 13). But it was reserved for Dr. Graves' pupil, Todd, to carry out this stimulating plan of treatment to its fullest extent, and to apply it more generally. During many of the earlier years of his life, Dr. Todd treated cases of acute disease like most practitioners of that day; and in his oldest case-books are records of cases of acute pericarditis which were bled and treated by mercury to salivation; cases of pneumonia which were treated by bleeding and tartar emetic; cases of fever in which a supporting plan was very hesitatingly and very imperfectly carried out. Slowly and gradually his treatment was much modified; and at length he became a strong opponent of the doctrines upon which the so-called *proper treatment* of inflammatory action was supposed to be based. Pericarditis and peritonitis were treated with opium without the mercury; stimulants were given, and the lancet was completely laid aside. Pneumonia was combated by counter-irritation and soothing poultices, and the skin and kidneys were made to act freely. The strength was supported; nourishing food was given; and if the powers of the patient flagged, brandy was administered, at first in small doses, but in many bad cases it was increased to

considerable quantities. Desperate cases of low fever and extensive internal inflammation were treated by very large quantities of stimulants, the amount being varied from time to time according to the symptoms present and the progress of the case; but the proportion was not limited by any inflexible or arbitrary rule.

It is, however, only during the last twenty-five years that we have actually demonstrated that alcohol administered in small and oft repeated doses does not *excite or increase the inflammatory process, and that inflammation may cease while a patient is taking considerable quantities of alcohol,* but even to this day, there remain not a few who are not convinced of the truth of these remarks. Some have fallen into the error of supposing that practitioners who advocate the use of stimulants in fever order large quantities in every case. Practitioners have been accused of giving brandy in a routine manner, inconsiderately and indiscriminately. But this is a very grave charge to make, and ought to be supported by those who prefer it, by reference to special cases. Mild cases of fever and inflammation were treated by Dr. Todd without stimulants altogether, or with very moderate quantities, but as this physician was naturally desirous of treating as many desperate cases of febrile disease as possible, a very large number of the worst forms of acute disease admitted into the hospital were placed under his care. The curious argument was adopted by some, that because very large quantities of alcohol

were administered in some exceptional cases, equally large doses were given by him in all cases.

Unfortunately the question of stimulation is one which has not always been considered upon its merits only. The zealous opposition to a particular practice upon religious, political, or moral grounds, may, without due care upon his part, quite unfit a man for the investigation of the effects of that practice upon the tissues of the living body under the varying circumstances of health, disease, climate, age, rest, anxiety, labour, etc. Such opposition ought to be discouraged.

Objections on account of the large quantity of Stimulants given.—Many objections have been offered to the "enormous amount" of stimulants given; but these do not rest upon any evidence advanced; and the arguments adduced against the system pursued have been satisfactorily answered. It seems never to have occurred to some, who have not hesitated to state the exact quantity of alcohol, which in their opinion should never be exceeded, that an amount which might be excessive if given to a person weighing six stone, would be but a moderate dose, and perhaps insufficient, in the case of one weighing three times as much. In this matter it is wonderful that people who pride themselves upon the practical tendencies of their minds, instead of allowing themselves to be influenced by facts and reason, should act as if every individual were exactly alike, and had been cast in

the same mould. Some persons are better treated without alcohol, while others, suffering from the very same disorder, require a good allowance of stimulant. The difficulties of explaining this and many familiar facts are great indeed—perhaps insurmountable in the present state of our knowledge. Many of us have remarked how readily some persons when exposed to contagion contract the disease, while others altogether escape, or if attacked, progress favourably in spite of circumstances the most adverse. Original hereditary defects affecting the organs of circulation and the nervous system, particularly weak heart, will doubtless account for some of the cases we have observed. There is reason to think that many children who die early might have reached old age if they could have been preserved up to the period of early youth. While there is no doubt that in other instances adolescence, or a still later period of life, constitutes the critical period when exposure to the influence of contagious poison might be more disastrous than at any other time of life. Such considerations must always influence our judgment in determining the proper treatment, especially as regards the quantity of alcohol. In the regulation of the amount of food for prisoners, the inmates of workhouses, hospitals, and charitable institutions, there is too great a desire on the part of the authorities to adopt uniformity; as if every individual required precisely the same quantity. The consequence is that a diet

which is low for some is more than sufficient for others. Some will be half-starved while others will be well fed—perhaps over-fed. Some of our hospital authorities are painfully inflexible in these matters, and are continually trying to discover a diet that shall equally suit patients of all ages and every kind of disease. The diet tables are changed every few years, and the physicians and surgeons continually blamed for ordering extras.* Under the uniformity system it is clear that, to the little people and the light weights is accorded a not perfectly fair advantage in the struggle for existence. It is of some importance for the physician, among other particulars, to take carefully into his consideration, when prescribing and regulating the proportion of food and stimulant, the weight and vigour of the individual patient. For although it is true that in proportion to their weight, small animals require much more food than large ones, a heavy man should, as a general rule, have a more liberal diet

* Surely the time has come when the Medical Staff of our great public charities should be permitted to exercise a little more influence in the management of the institutions in which they are the chief workers than heretofore. In some of our London hospitals any single member of the Committee, or the Secretary, who may be completely unacquainted with disease, and quite unable to judge of the requirements of the sick, exercises more control in the management of the institution than the entire Medical Staff. In some cases, the Medical Officers are far too much in the position of servants, who are expected to execute the orders given by the authorities under whom and for whom they are supposed to work. It is, however, very doubtful if such relationship between those who manage the institution and those who are responsible for the treatment of the sick is the most advantageous that is possible.

than a light one; and in apportioning the quantity of stimulant to the sick, this fact must not be neglected. But it must at the same time be borne in mind that by habit and other circumstances some persons have been led to take, and hence require, a larger proportion of food and stimulants than others of the same weight.

In low diseases, the quantity of stimulants required during a short period may be very large; indeed, the patient's life seems sometimes to depend alone on the frequent doses of alcohol (occasionally as much as an ounce or even two ounces an hour) which are poured into the stomach and taken up by the blood; and it is remarkable that as long as the case does well, the stimulant seems to be absorbed almost as fast as it is introduced into the stomach: a little escapes in the urine, in the breath, and perspiration, but by far the larger portion is used up in the system (p. 389); and in two or three different ways helps to keep the patient alive at a time when the disease places him in the greatest jeopardy.

It was pointed out more than twenty years ago, that in some cases, the period of convalescence was much shortened; in cases necessarily fatal, life was prolonged; and it is believed that many desperate cases of low fever, pneumonia, acute rheumatism, etc., have been saved by the administration of large quantities of stimulants. If a collection could be made of some of the most serious instances of febrile diseases that have recovered under alcohol from the practice of

a considerable number of medical practitioners, I feel sure that so strong a case would be made out in favour of this mode of treatment, that it would be generally adopted. Moreover, there are cases which have injudiciously been "given up" by the doctor that have recovered under the administration of stimulants, and it has occasionally happened that the delirious state has been relieved by an act performed by the patient in his delirium. Dr. Winn sends me the following interesting remarks in connection with an instance of this:—"As regards the use of alcohol in disease, I learnt a lesson when a student which I have never forgotten. I was attending the Fever Hospital at Glasgow, a city which was then quite a hot-bed of fever, and I went there with my mind fully imbued with the antiphlogistic theories. Imagine my surprise on finding that the chief remedy employed, and successfully too, at that hospital, in the worst cases of typhus, was whiskey in frequent and large doses. I can now recall one case in particular, that of a patient in a state of acute delirium, whose head became quite clear after imbibing a bottle of whiskey in about 24 hours!"

It may then be regarded as certain, that in a number of cases, advantage has resulted from giving very large quantities of stimulants. Several remarkable instances will be found reported in Dr. Todd's Clinical Lectures.* But among the most striking are

* "Clinical Lectures by R. B. Todd, M.D., F.R.S." Edited by Lionel S. Beale.

the two cases already alluded to, which have been recently recorded by Dr. Wilson Fox. Alcohol is the most powerful remedy we possess, and probably the only one by which we are enabled to save life in desperate cases cf fever.

When considering the circumstances which lead to death in severe cases of fever, I showed that the failure of the heart's action, the alteration in the composition of the blood, and the obstruction of the capillaries, and the consequent interference with the process of nutrition, all contribute to bring about a fatal result. Now in slight cases frequent doses of alcohol tend to prevent these occurrences, and when the attack is severe, to mitigate its severity, to postpone the occurrence of the dangerous phenomena, and to prevent them from progressing to such an extent as to render a fatal result probable.

Alcohol, then, exerts a two-fold action when given in cases of fever. It acts *directly* upon the nerves of the stomach, and through these excites almost instantly increased contraction of heart. The less *direct* action of alcohol is much more complex, and occurs more slowly, for before it can exert the indirect influence I refer to, it must be absorbed by the blood and circulated with it to all parts of the body. Although I have drawn attention to the facts upon which my views concerning the important indirect influence of alcohol are based, the subject is of such vast practical importance, that I shall offer no apology

for passing in review the several scientific arguments, which, it appears to me, prove conclusively the way in which, by the judicious use of this most important remedy, the saving of life is effected. But first, a very few words as to the direct action of alcohol.

1. *Direct Action of Alcohol in keeping up the Heart's Action, and promoting the Capillary Circulation.*

Now as to the probable action of alcohol in saving life, and retarding a fatal result in desperate cases of fever and extensive internal inflammation, I will remark that its value in exciting the heart to more vigorous contraction is admitted by all. The fact is in accordance with the actual experience of many of the effect of stimulants upon themselves, and physiological experiment has proved that by the action of alcohol upon the nerves of the stomach, the heart's action is accelerated. The value of stimulants in promoting the capillary circulation has been recognised by several physicians, but Sir D. J. Corrigan especially has dwelt upon the great importance of giving alcohol in fever, because it maintains the flow of blood through the minute vessels of the tissues of the body. In his lectures on the treatment of fever, published in 1853, and containing the results of great experience, and many years of careful observation, occurs the following passage, which deserves to be quoted at length :

"Ask yourselves for what is it in typhus fever you prescribe wine? Is it for delirium? No. Is it to prevent its approach? Again no. Do you give it for a dry tongue? Certainly not. What is it that, as you consider a patient's state, would lead you to think of its employment? Is it not the state of the function of circulation, taken as a whole, indexed to you by the pulse on the one hand, and by the state of the capillary system of circulation in the skin, on the other?

"It is for this you give it. It is the specific remedy directed to remedy the general lesion of the function of circulation, and hence in its administration you may give it whether there is or is not delirium; for delirium may be present or absent in a case requiring its exhibition for the function of circulation. You should give it indifferently whether the tongue is moist or dry; for the tongue may be either, and yet wine may be required; and hence the tongue's becoming moist is not an indication that you may dispense with its use, nor is its continuing dry a sign to make you discontinue it. You may give it with a soft abdomen, or with an abdomen tympanitic, for similar reasons. You are giving wine recollect, as the specific remedy for the lesion of the function of circulation (remember always, comprising under this the capillary and cardiac circulation); and by the state of pulse, and changes in the colour of the maculæ, you are to judge of the necessity of continuing, decreasing, or augmenting its dose. Under

its exhibition you will see the vessels of the conjunctiva contract, the maculæ become rose coloured, and the patches of skin on dependent portions of the body lose their dark livid hue. Keep this, then, in mind—the lesion in fever for which you give wine, is the lesion of circulation; and if this function from debility require it, you must give it under all circumstances of derangement of other functions."*

2.—*Indirect Action of Alcohol on the Blood and on the Bioplasm of the Tissues.*

In order that a correct idea may be formed of the manner in which the indirect action of alcohol upon the constituents of the blood and upon the bioplasm in fever and inflammation is effected, it is necessary to direct the reader's attention to some questions of scientific detail, some of which may appear only very remotely connected with the subject, but which are nevertheless important, partly because they indicate precisely the change which is effected by the agent, partly because they enable us to correct erroneous theories which have hitherto been acted upon. And first as regards the conclusions formerly taught, and still to some extent believed, concerning the value of bleeding in fever and inflammation.†

* "Lectures on the Nature and Treatment of Fever," by Sir D. J. Corrigan, Bart. Page 58. Fannin & Co., Longmans, 1853.

† The views put forward in the following pages have been taught by me since the year 1860, and will be found published in the *British Medical Journal* for 1863.

Of Bleeding, and the Life of the Blood. Vital Stimuli, and of the life-giving and renewing Theory.—From the earliest ages those who have devoted themselves to the study of disease, have regarded the condition of the blood as of the highest importance. To a bad state of this fluid many ailments have been correctly ascribed. To alter this state was and is the main object of treatment. Modern research has confirmed the opinion so long and so generally entertained with reference to the high importance of a healthy state of blood; and modern practice is eminently conservative of this fluid. Of late this view, like every other correct doctrine, has been assailed and doubts cast upon its correctness, but it has not suffered from the attack.

The principles upon which the removal of large quantities of blood was advocated and carried out at various periods in the history of medicine have been proved to have been founded upon incorrect data. The old theories of inflammation even yet maintained by some, have been completely upset by observation and experiment. The blood, which used to be freely drawn for the purpose of reducing an excess of action, is now considered, and in cases of the very same class, to be absolutely necessary for the recovery of the patient. It has been proved conclusively—1. That morbid changes, which were formerly supposed to be checked by bleeding, really continue in spite of it; and 2. That by violent bleeding the general condition of

the patient is rendered much more serious than before. Formerly a patient was bled to *cut short the disease;* now, he is bled only for the purpose of relieving the tension of over-distended capillaries.

The blood has been, and still continues to be, regarded as a living fluid which carries life to all the tissues. Vital power is said to be reduced by abstraction of blood. Vital power is said to be restored or "renewed" by those remedies which increase the quantity of blood or improve its quality. That the blood is the medium by which nutrient matter is distributed to all the tissues of the body, is beyond question. That its qualities are altered in disease, and that in many instances the blood is as it were the starting point of certain morbid changes, is undoubtedly correct. But that the blood transmits *vital power* to the body generally, to the tissues of the body individually—that vital power is diminished by its abstraction, or increased by any alteration occurring in the blood—seems to me utterly untenable. There is no reason whatever for assuming that what we call *vital power* can be carried from one place to another by any fluid or solid, and distributed to structures in a distant part of the body. Nor is it probable that this wonderful vital power can be added to or taken from any tissue at all. When we give stimulants, we do not increase *vital* power at all. The blood will, I dare say, continue to be called a *vital fluid,* but the term is not correct; for there

is every reason to think that the soluble albuminous constituents, and the red blood-corpuscles, are as inanimate while circulating in the vessels of the living body as they are after the blood has been withdrawn from the vessels.*

Every kind of pabulum and every stimulant, like every narcotic, and every medicinal remedy is inanimate. Everything which contributes to nutrition is lifeless. Living matter never lives upon *living matter*. The pabulum of the tissues, especially in the case of man and the higher animals, results, no doubt, entirely from the death of living matter ; but, as pabulum, it is inanimate. But although the blood is not a living fluid, it contains masses of living matter (colourless corpuscles and minute particles of bioplasm in great number), and many corpuscles which are not living (fully formed red corpuscles).

Neither blood, nor lymph, nor chyle, nor cod-liver oil, nor alcohol, nor any nutritive substance whatever, can be correctly spoken of as *life-giving*. Nor do certain conditions call forth "*vital energy*," or act as "*vital stimuli*," or increase vital power which already exists. Heat, various external conditions, and excitants or irritants, as they are termed, act

* The matter of which each red blood-corpuscle is composed, tends to assume the crystalline form when its movement ceases. This is well seen in Guinea-pig's blood. Each red corpuscle becomes a tetrahedral crystal. This fact is conclusive against the notion that red blood-corpuscles are in an active state of vitality. Living matter does not crystallise.

simply by diminishing to some extent the restrictions under which life is ordinarily carried on,* and thus pabulum is permitted to come more readily and more quickly into contact with matter that already lives.

What happens in Nutrition.—The food that is absorbed in an altered state by the blood does not transmit life to the tissues; for as I have shown every tissue contains in its substance matter in a state of active vitality or *bioplasm.* The pabulum that passes from the vessels and permeates the lifeless tissue is inanimate. It comes into contact with the living matter; and certain of its constituents then acquire at once vital properties, powers or endowments. By contact with and absorption into the living, life is communicated to that which was lifeless. There is no reason to suppose that living matter (for instance, the so-called "nucleus" of a cell) exerts any influence upon matter at a distance from it; but it appears probable that in all cases the changes which occur in nutrition are simply these:—

The inanimate pabulum permeates the inanimate tissue (cell-wall, intercellular substance), and comes into contact with the living or germinal matter or bioplasm. Certain of the inanimate constituents of the

* This view concerning stimuli, excitants, and irritants, is discussed in a short paper published in the *Lancet* for December 6th, 1862, and was a year or two afterwards more fully considered in papers published in the *Medical Times.*

pabulum become bioplasm. Particles of the living matter or bioplasm after a time undergo change—in fact die, and become gradually converted into inanimate "cell-contents," "cell-wall," or "intercellular substance." These inanimate *formed substances* may accumulate and undergo condensation and other physical and chemical changes, or they may be resolved by the action of water, oxygen, and the like, into new substances as fast as they are produced. Such new matters produced by the agency of the bioplasm of "gland cells" may pass into a tube or duct, and in many cases constitute a secretion.

The rate at which bioplasm grows and is reproduced, is determined solely by the facility of access of the proper pabulum ; so that, if nutrient matter comes into contact with the living matter readily, the living matter increases rapidly. In short, the more it is fed, the faster it grows. The *power* of growth on the part of living matter remains the same, but actual growth always occurs under certain restrictions. The restrictions or impediments to the access of nutrient matter vary in different cells, and in the same cell at different periods of its existence. Alcohol and many other substances cause changes which result in increased impediment of access of nutrient matter.

Alcohol is not a Food but is absorbed as Alcohol.—It is probable that whenever alcohol is taken, a certain proportion, which increases as the dose is augmented, passes into the blood and circulates with that fluid as

alcohol. It may permeate the tissues and produce changes in them. Many other active agents are taken up by the blood, and under certain circumstances produce a direct action upon the tissues. These substances may then undergo change, and perhaps be completely decomposed, and their elements excreted in an altogether different state of combination from the body. Being transmitted by the blood to different parts of the body such soluble materials may modify the growth of tissues and affect the rate at which growth takes place. Nay, we know that by certain soluble matters introduced from without circulating with the blood the formation and growth of tissues may be actually prevented. For the further elucidation of the matter under consideration, it is desirable to refer briefly to the varying rate of growth of bioplasm under altered conditions of life.

Of slow and rapid growth.—We can tell at once, by the characters of a cell, whether it has been growing quickly or slowly. Whenever the outer part of the cell (formed material) is firm and hard, and not very permeable to nutrient matter, the growth must have been slow. Where on the other hand, the envelope is very thin, or where there is no envelope or cell-wall at all, the greatest facilities for rapid growth exist. Contrast the pus-corpuscle, consisting almost entirely of bioplasm, which has grown perhaps in the course of a few hours, with a fully formed cuticular cell, in which the bioplasm is surrounded by a very thick

layer of slightly permeable cuticular substance. The restrictions under which the growth of the bioplasm of the last is carried on are far greater than those which limit the growth of the first. But anything which renders the wall of a slow growing cell more permeable will facilitate the access of pabulum, and its bioplasm will then increase more rapidly. Thus rapidly-growing bioplasm may spring directly from bioplasm which has been growing very slowly. Pus may result from the rapid growth of the bioplasm of epithelium, fibrous tissue, nerve, or other tissue which has been growing very slowly (*see* page 114). Cancer grows faster than healthy epithelium or other normal tissue, but not so fast as pus. Epithelial cancer is less permanent as a tissue, and grows more quickly than the normal epithelium, but it is more lasting than pus and less quickly produced. On the other hand anything which tends to coagulate or harden bioplasm on its surface will have the effect of retarding its growth.

Disease is not due to defective action.—From the considerations advanced in the last few paragraphs it must be clear that the doctrine that disease is a *deficiency of action* must be erroneous. The idea that support is required to counteract this tendency to depression of the vital powers is purely fanciful, as is also the notion that something extra must be added in order to make up for the loss occasioned by the diseased state. Although we see structures in disease growing so fast that difference in bulk is perceptible from

day to day, still pathologists continue to talk of "*deficiency of action*," "*defective vital power*," "*diminished vitality*," as if it was certain that by these phrases the phenomena of disease were to be explained. The surgeon "*stimulates*," the wound with caustics, and fancies that he "increases" the "*vitality*" of the surface just below; the physician pours in brandy, and supposes that he "*increases the vitality*" of the affected tissues. But it is easy to prove that by these measures, many cells that were alive are *killed*, and that those that escape death live and *grow more slowly than before.* This *diminished rate of growth and life* is really what is required. It is indeed the very condition which approaches to the healthy state. But then it is, as compared with the morbid state, the very reverse of "*increased vitality*."

Probably even now most physicians would affirm that there was deficiency of vital power in a case of low pneumonia; and yet what evidence is there of such deficiency? It is true, the patient is weak and cannot move; he may be delirious; all his muscles may be relaxed; his heart's action may be weak; and he may be dying of exhaustion; but has it been shown that weakness, or inability to move, or delirium, or relaxed muscles, or weak heart's action or what we call "exhaustion," are due to diminished vitality, to depression of *vital power?* It is very well to say that in this particular morbid change there is "excess of action," and in that one there is "deficiency,"

or in all disease there is deficiency of action; in this condition, "the vital powers are depressed, and we must give support;" and in another, "the vital powers are too active, and must be restrained;"—but these are, after all, but arbitrary phrases, and the same words are used in very different senses.

Surely then it will be more correct to say that a patient is low or weak, than to say that he is suffering from a depressed state of the *vital powers*. The former phrase asserts a fact; the latter expresses a theory. We talk of excess of action, and diminished action, before we have agreed as to what we mean by the terms. If we attribute rapid growth, rapid change, to increased vital activity, then most unquestionably do many diseases which have been accounted for by some supposed diminution of vital power, really depend upon an undue manifestation of vital action.

Conclusions.—It will be observed that, in these conclusions, I differ materially, and in fundamental principles, from the views generally entertained. Men may agree as regards practice, although they differ materially in opinion as to why certain measures ought to be employed in a given case. But when good practice rests upon unsound theory there is always great danger of the practice being abandoned when the theory is overthrown. This in part explains why we vacillate from one extreme of practice to the other, and why to some extent, we seem to work in recurring circles. Earnest men not unfrequently are found to be

sceptics upon the question of the proper management of disease; and, in the course of years, most valuable practical conclusions, arrived at from actual experience, are forgotten, because the theory upon which these conclusions were based has been overthrown and proved to be unsound. But why, for example, may we not retain in practice the depleting process in those cases in which it has been proved to be of service, although the principles upon which depletion was carried to foolish extremes have been proved to be erroneous? And on the other hand, why may we not continue to carry on the system of stimulation in cases in which stimulants are known to be useful, although it may be quite true that stimulants neither support life, nor give life, nor nourish tissues, nor supply the place of food, nor directly affect the disintegration of tissues?

So far from the abstraction of blood diminishing the nutrition of bioplasm, the process may actually be increased by violent bleeding. The blood that remains becomes weaker, and the watery parts necessarily permeate tissues more readily. Thus rapidly growing cells, such as exist in the air-cells in pneumonia, grow still faster, because they are supplied more freely with nutrient pabulum. On the other hand, alcohol in several ways interferes with the growth of these bioplasts, and thus tends to put a stop to the "inflammatory process." The results of practice in fact support *this* theory: that in low conditions of the system, and by

profuse bleedings, the growth of adventitious products is *accelerated;* and that such growth is retarded by alcohol, acids, and some other substances.

Of support.—Further, as regards the meaning of the term "support," it is necessary to make a few observations. In cases of exhausting disease, we all talk very freely in these days of the importance of *support;* and many physicians would regard alcohol as the most valuable of all kinds of support given. Nevertheless, in these very cases the patient, in spite of all the support, loses many pounds in weight, and in the course of a few weeks or even days; nor is it possible by any known means to prevent this result. And it is a fact that, in many of the worst cases I have seen, although the stomach seemed to do its work perfectly, and the quantities of supporting matter consumed by the patient were very great, the emaciation was extreme. The patient, under these circumstances, has been kept alive long enough to become extremely emaciated. Such emaciation would not exist if the patient were left to nature, because death would have occurred before matters had proceeded to this extremity. But it does not follow that he has been kept alive by food or by matters that support like food. In these cases, I feel confident that the stimulant is really the agent which has kept the patient alive; for it sometimes happens that patients will not take any form of nutriment; and not unfrequently the stomach will bear whiskey or brandy, and in large quantity, where it instantly

rejects beef-tea, milk, and other "nutritious substances." From what I have observed, I think it possible that a patient suffering from low pneumonia, or from a very severe form of continued fever, or acute rheumatism complicated with pericarditis and pneumonia, might be kept alive until the disease subsided by alcohol alone, but not because the alcohol acts like food and supports him and nourishes his tissues. It is certain that the alcohol does not nourish the tissues in the ordinary sense of the word, and if it diminishes the waste of the tissues in these cases, it must be admitted that it is difficult to conceive waste more extreme than that which has taken place while the patient has been taking large quantities of alcohol. But the patient lives; and so many account for the result by concluding at once that the alcohol must be a "*supporter of life*," although they are aware that this same alcohol, administered in the very same quantities in the healthy state, might destroy life.

There is not a more important question in medicine to be determined than the action of alcohol in disease; for, while it has been conclusively proved that it is not a food and does not directly nourish the tissues, there cannot be the slightest difference of opinion among practical men concerning its value as a remedy. We differ widely in our views as to the extent to which alcoholic treatment should be carried in a given case, but almost all agree that in some cases alcohol ought to be prescribed and in considerable quantities.

Action of Alcohol.

Chemical action of alcohol.—It seems to me that we should not ignore the probable chemical action of alcohol upon important constituents of the blood. It is scarcely possible to believe that the large quantity of alcohol taken by many patients does not influence the permeating properties of the fluid part of the blood, and cause some chemical alteration in the soluble constituents which belong to the albumen class, besides exerting a local action upon soft and rapidly growing bioplasts. Many of the so-called *tonics* have the property of coagulating albuminous fluids and solutions of extractive matters. Preparations containing tannin, the mineral salts, such as the sulphate and sesquichloride of iron, nitric and hydrochloric acids, and a host of other substances employed as remedies, that will occur to every one, possess this property, and render solutions containing albuminous and allied matters less permeable, perhaps by increasing their viscidity. The favourable action of such remedies may be due to their direct influence on the fluid constituents of the blood. They, no doubt, also cause a reduction in the rate at which blood-corpuscles are destroyed, and at the same time they tend to render the walls of the blood-vessels less permeable to fluids.

But, of all the remedies we possess, I believe alcohol acts most rapidly in this way, and in particular

cases most efficiently. The properties alcohol possesses of hardening animal tissues, and of coagulating albuminous fluids, are well known; and these properties must not be forgotten when its effects in the animal body are discussed. Of course, when absorbed by the blood of a living person, alcohol does not actually *coagulate* the albuminous matter; but it probably renders it less fluid, and reduces its permeating property. Alcohol interferes with the disintegration of blood-corpuscles; and in cases where this is going on very rapidly, and where fluid is passing through the vessels in considerable quantity, in consequence of the thin vascular walls themselves being stretched and rendered too readily permeable to fluids, alcohol is likely to be of service; but where these changes are proceeding very rapidly, and the patient's strength is fast ebbing, it may save life.

We may, therefore, explain the beneficial action of alcohol without assuming that it is a food, or contributes directly to the ordinary process of nutrition. Nay, if it merely filtered through the blood-vessels, and left the body by different emunctories as fast as it was introduced, we could account reasonably for the good effects we frequently observe when alcohol is given in certain forms of disease.

Action of alcohol upon growing bioplasm.—If there be a little abrasion of the cuticle, around which the skin looks red and angry, the neighbouring tissue being hot, swollen, and painful, the capillaries

distended so as to produce bright redness, it will be found that the occasional application of a drop of alcohol to the affected part will in the course of a single hour produce great changes. In and around such a spot, it is quite clear that we have not *diminished*, but *increased* action. Numerous small particles of living bioplasm ("cells") are receiving an unusual quantity of soluble nutrient substances, and are in consequence multiplying rapidly in the deep layers of the cuticle. The bioplasm of the nerves, capillaries, and connective tissue of the cutis, are larger than they were in the healthy state; the living matter is growing, dividing and subdividing into smaller portions, which will grow and again divide and subdivide. In the capillaries, and just external to them, are numerous white blood-corpuscles, varying in size from small points to particles having the ordinary dimensions of these bodies. These, like the living bioplasts of the tissue, are rapidly increasing in size. The capillaries are gorged with blood, and the thin walls of many of them are stretched to the utmost. Now what happens when a drop of alcohol is applied to such a sore? Momentary pain, followed in the course of a few minutes by great relief, or complete cessation of pain, and diminished vascularity. But how does the alcohol bring about these striking changes? If alcohol be added to any serous fluid, as is well known, the albumen is precipitated. If delicate masses of bioplasm are placed in alcohol, and afterwards

examined under the microscope, every one knows that they will appear "very granular," and they will have become shrunken and altered much in form; and it will be found that they will resist disintegration by pressure to a greater extent than in their natural state. By the action of alcohol, the surface of a wound is much altered, and it soon becomes covered with a dry crust. This results from the hardening effects of the alcohol. Some of the rapidly growing particles of bioplasm are quite destroyed, while others become surrounded with an envelope of hardened matter, which prevents the possibility of their absorbing nutriment and giving rise to new particles, and growing and multiplying as rapidly as before. Not only so, but the permeating power of the nutrient fluid itself is reduced by the tendency of the alcohol to coagulate it. The most superficial of the particles of bioplasm would be destroyed by alcohol, though not so quickly, perhaps, as they would have been by the actual cautery, nitrate of silver, sesquichloride of iron, sulphate of copper, etc.

Of the Action of Alcohol on the Vessels of an Inflamed Part.—Next comes a more difficult question for consideration: How does the alcohol cause the vessels of the inflamed part to contract, and permit the flow of less blood through them? If we press upon the distended vessels of an inflamed part, as is well known, the blood is driven out of them, and the skin becomes quite pale; but the moment the pres-

sure is withdrawn, the redness recurs, and exhibits *precisely the same tint* as before. From this it is clear, not only that the capillaries are unduly distended, but that the calibre of the small arteries through which the blood is distributed to them is much larger than in the normal state. Besides this, we are able to prove by this simple experiment that the vessels may be maintained for a long time of a given calibre. Such a state of things can only result from a certain regulated but definite influence upon nerve-centres which govern the calibre of the small arteries (p. 330). The temporary change induced in the nerves can be maintained at one definite degree for a considerable time In this way the quantity of blood permitted to flow through the capillaries in a given time is regulated and varied within certain limits. The mechanism is such that a small artery is made to assume and to retain for a longer or shorter period a different calibre, although this may be momentarily altered by artificial means.

Now I believe that the alcohol passes through the walls of the capillaries, and acts directly upon the nerves, which I have shown are distributed just external to them.* By these *afferent* nerves the nerve-centres are influenced, and in consequence, the intensity of the current transmitted by the vasa-motor nerves of the small arteries is modified. That alcohol affects the nervous system very readily is

* See *Archives of Medicine*, No. xiii. *Phil. Trans.*, 1863. *Monthly Microscopical Journal*, Jany. 1872.

proved by its remarkable effects upon healthy persons. Can we then believe that in extreme cases of low disease, in which the nervous phenomena appear almost as in the healthy state, although a patient takes more than enough alcohol to intoxicate a healthy man, that the alcohol exerts no influence whatever? True, that in many cases, so little is the ordinary action of alcohol manifested, that a patient may be taking an ounce of brandy every hour, and a bystander would not believe he was taking alcohol at all. Yet surely no one would maintain that therefore the alcohol is powerless and produces no more effect than so much water or any perfectly inert substance. That alcohol will produce delirium in health, and remove or prevent the occurrence of delirium in an exhausted state of the system, are facts, but they cannot be fully explained in the present imperfect state of our knowledge concerning the action of nerve-centres and nerves, especially the nerve-centres which control vascular phenomena.

Action of Alcohol upon Bioplasm outside Vessels in Pneumonia.—I propose now to consider what is actually going on in pneumonia, and shall endeavour to account in some measure for the beneficial action of alcohol in bad cases of this disease. The air-cells of the lung are filled with multitudes of living actively growing particles of bioplasm which have passed through the vascular wall with the serum, and are now absorbing nutrient pabulum at a very rapid rate; and

probably, as these particles increase in number, an increased proportion of pabulum is diverted from all parts of the body to the "focus of inflammation," where they are multiplying. We *know* positively that a determination of common salt does actually take place to this spot; and it is therefore perfectly reasonable to infer that other matters are in the same way diverted from their usual destination, and absorbed here, instead of being used up in the ordinary changes occurring in the normal state. (*Med.-Chir. Trans.*, vol. xxxv, 1853.) I have already spoken of the pabulum which in a fluid state transudes through the stretched walls of the blood-vessels, and feeds the particles of bioplasm which in inflammation lie just outside them. Not only are the capillaries more readily permeated by reason of the stretching and consequent thinning of their walls, but the fluid in the blood vessels possesses a greater tendency to permeate animal membrane; so that it would seem but reasonable to consider whether anything can be done to diminish this by altering the character of the fluid itself.

Let us now consider how alcohol acts upon the elementary parts of the living organism, and in order to render the arguments upon which my views are based intelligible, it will be as well to direct the reader's attention in this place to some points which may have been already referred to more than once in this volume.

In the treatment of a sore upon the surface of the body, the means we adopt in order to promote the healing process check the free and rapid growth of the bioplasm. The commencement of the healing process is associated with more slow nutrient change. *See* p. 422. In the same manner what we desire to effect in the treatment of internal inflammations and the feverish state, is to check the undue growth of bioplasm which is proceeding in the blood in certain parts of the body, and in the "inflamed" tissues or organs. This bioplasm can only be reached through the blood. And it can be shown that the remedies which have been proved by experience to be of value in the treatment of such cases, possess the property of checking the redundant growth of bioplasm and can be taken up by the blood and distributed through the body without losing their properties. Now in many extensive internal inflammations such as pneumonia and pericarditis, it seems to me probable that the alcohol taken up by the blood really acts directly upon the morbid bioplasm growing and multiplying so very rapidly just outside the capillary vessels, and checks the process. It will be asked upon the theory I have ventured to propound: How it is that the alcohol acts upon the morbid and not upon the healthy structure? But this question is not difficult to answer. The healthy cells being surrounded by a thick protective covering or embedded in a matrix (cell-wall, intercellular substance), are not

affected by it; while the morbid cells, growing so fast that time is not allowed for the production of a hard external envelope, are fully exposed to the free action of soluble matters which transude from the blood. These, therefore, undergo the changes already described, and are caused to increase more slowly, while many are destroyed. In the growing cells in the air-cells of a hepatized lung, then, there is no evidence of *deficiency* of *vital* power; and the remedies which act favourably really seem to act, not by *increasing vital power*, but by diminishing *the rate at which vital changes are proceeding*—in fact, by causing particles of bioplasm which were living *too fast* to live *more slowly* and by causing *the death* of many.

Author's View supported by many General Facts.—This explanation of the action of alcohol is in harmony with many broad facts familiar to all. By it we may account for the shrivelling of the hepatic cells, the shrinking of the secreting structure, and the increased hardness and condensation of the entire liver, which result from the continual bathing of the gland-structure by blood almost constantly loaded with alcoholic poison. It explains the gradual shrinking and condensation of tissues which occur in persons who have long been accustomed to excess. The tendency to increased formation of adipose tissue which occurs in many of those who live generously, and seems to be augmented by alcohol, may be explained upon the same view, and the stunting in growth which follows

its exhibition to young animals is also accounted for.

Action of Alcohol upon the production of Heat.—In a slight catarrh in a healthy man, six or eight ounces of alcohol did not lower the temperature, which however was only 100·7 (Parkes & Wollowicz). This fact cannot be advanced as an argument against the value of alcohol in cases of fever and internal inflammation. In slight febrile disturbances there is no doubt whatever not only that alcohol in large quantities does no good, but that it does positive harm, by exciting the heart's action unduly and tending to produce narcotism. In very low states of system, however, albuminoid matters are fast escaping from the blood, the blood corpuscles are undergoing rapid disintegration, *and the living matter or bioplasm* of the vessels of the neighbouring tissues and of the blood is growing very quickly. The changes referred to are associated with a rise in bodily temperature. Alcohol, as has been shown, tends to modify all these phenomena. And I believe that by further research in the same direction we shall succeed in giving a full and thoroughly satisfactory explanation of the action of alcohol in lowering the body heat in severe attacks of fever.

Summary.—The observations upon the action of alcohol on the "cells" or elementary units of the tissues justify us in concluding that its beneficial influence in very bad cases of disease is due in part to its action upon the pabulum and its tendency to render

albuminous solutions less permeable, and partly to its direct action upon particles of naked and living bioplasm. Alcohol reduces the permeating tendency of the serum; it checks the disintegration of blood corpuscles; it prevents the rapid growth of living matter; and interferes with or modifies chemical changes taking place in organic fluids. When these changes are proceeding very rapidly, the capillary circulation beginning to fail, the heart's action becoming very weak and fluttering, and the strength ebbing fast, alcohol may save life.

In conclusion, the local and general action of alcohol may be shortly summed up as follows:—

1. In external wounds, and in internal diseases where alcohol acts beneficially, the good result is in part at least due to the alcohol checking the *increased action* already established.

2. Alcohol does not act as a food; it does not nourish tissues. It may diminish waste by altering the consistence and chemical properties of fluids and solids. It cuts short the life of rapidly growing bioplasm, or causes it to live more slowly; and thus tends to cause a diseased texture, in which vital changes are abnormally active, to return *to its normal and much less active condition.*

3. In "exhausting" diseases, alcohol seems to act partly by diminishing very rapidly the abnormally increased growth of bioplasm. The quantity required will depend upon the extent to which the changes alluded to have proceeded. In extreme cases, half an

ounce of brandy, or even more, may be given for a time (in some cases even for several days) every half hour; and there is reason to believe that, in desperate cases, life is sometimes saved by this treatment.

Practical Conclusions.—Lastly, I shall venture to repeat here the conclusions I arrived at many years ago concerning the great value of the alcoholic treatment of low fevers and inflammations. Increased experience has afforded further confirmation of the correctness of the statements made in the paragraphs below. I do not, of course, refer to slight cases of fever, pneumonia, &c., in which no stimulant whatever may be required, but to *very severe cases of disease* only.

1. In what appeared hopeless cases, as much brandy as the patient could be made to swallow (an ounce and a half to two ounces in an hour) has been given for several hours in succession, and then as much as thirty ounces a day for several days, not only without producing the slightest intoxication, vomiting, or headache, but the treatment has been followed by recovery.

2. I would adduce the fact that a man not accustomed to drink, when suffering from acute rheumatism, complicated with pericarditis with effusion, pneumonia at the base of one lung, and pleurisy on the opposite side, has taken twenty-four ounces of brandy a day for eleven days; the tongue being moist and the mind calm during the whole time. While under this

treatment inflammatory products were absorbed, and the general state of the patient much improved.

3. I have been compelled to give a very weak child, weighing less than four stone, twelve ounces of brandy a day for ten days, while suffering from acute rheumatism with pericarditis and effusion. This quantity did not produce the slightest tendency to intoxication, or exert other than a favourable effect upon the disease. The patient did not begin to improve until the quantity of brandy, gradually increased, had reached the amount stated.

4. I would state that, among the general conclusions I have arrived at after carefully watching more than one hundred serious cases of acute disease treated with large quantities of stimulants, are the following:—*That intoxication is not produced,—that delirium, if it has occurred, ceases, or is prevented from occurring at all in the course of the case,—that headache is not occasioned,—that the action of the skin, kidneys, and bowels goes on freely—that the tongue remains moist, or, if dry and brown, often becomes moist,—that the pulse falls in frequency and increases in power,—that respiration is not impeded, but that, where even one entire lung is hepatized, the distress of breathing is not increased; and it appears that the respiratory changes go on under the disadvantageous circumstances present, as well as if no alcohol had been given.**

* *British Medical Journal*, 1863.

The conclusion from all this is most certainly, that alcohol does not do harm in fevers and acute inflammations; that it does not produce intoxication in persons suffering from exhausting diseases; and that large quantities (from twelve to thirty ounces) may be given in cases which appear very unlikely to recover: and the conviction is forced upon the observer that, in desperate cases, these large quantities of alcohol are directly instrumental in saving life, not by *exciting or stimulating to increased action, but by moderating actions already excessive*, and at the same time by causing the heart to contract more vigorously and so continue to drive the blood through the impeded capillaries, as has been pointed out.

Of Acids and Tonics.

Treatment after the Cessation of the Febrile State.—To facilitate as far as possible the removal of noxious materials which have been already formed and have accumulated in the blood, to prevent the formation of more, and to guard against nervous exhaustion, seem to be the principal objects to be gained by treatment during the continuance of the febrile state. When, however, the excrementitious substances which have been accumulating in the blood have been excreted—after free perspiration has occurred and the scanty secretion of urine loaded with urates and perhaps containing excess of urea has been succeeded by the free flow of watery urine; when the circulation through

the capillaries is restored, and the blood, though reduced in quantity, is slowly returning to its normal quality and state ; when the temperature has fallen to the normal standard, when the glands of the stomach and intestine are resuming work, the liver and kidneys are acting freely, the further prosecution of the treatment that has been recommended would be useless, and might do harm by prolonging the convalescence and retarding the return of healthy strength. This is the time when the organism is returning to its normal state, when "nature's efforts" may be assisted, and the return to health expedited by judicious medical treatment. Still the patient must be regarded as an invalid, and the greatest care exercised. The organism will not bear any fatigue, and injudicious muscular exertion may be followed by coagula forming in the capillaries or veins. Thus may commence a second illness. It is not until some weeks after an attack of fever that the blood and the tissues of the body regain their perfectly healthy state. The mineral acids, iron, bark, salicine, quinine, and many of the bitter tonics, given with care and judgment will assist the action of the stomach and promote the formation of new blood. Small doses of dilute hydrochloric and phosphoric acids with pepsin before meals often expedite the return to the normal state of health. If profuse sweating continues too long, it may sometimes be checked by quinine and acid, by small doses of sulphate of zinc and other remedies. Alkalies in

small doses may still for some time be required after meals, and in many instances certainly influence favourably the latter part of digestive process, and I think specially aid the assimilation of wine. Now and then it will be necessary to give a mild purgative or a simple injection.

Of the Sick Room.

Of the Bed-room.—The room which is occupied by a patient suffering from febrile disease should be large and well ventilated, but the position chosen for the bed should be that most free from draughts; for there is no doubt that cold air in active motion playing over the face of the patient is likely to excite catarrh or inflammation of the air tubes or lungs, besides which, to most persons, it is intensely disagreeable. And with a little management, the free interchange of air can be effectually provided for without subjecting the patient to the miserable discomfort caused by moving air constantly playing across his face. In mild weather the window may be wide open, a sheet being drawn across at a short distance in front of it, if the bed be very near; in winter, by the aid of a piece of thin board so fixed to the upper sash that when the window is opened a few inches, the current of air is directed towards the ceiling. If muslin, or coarse gauze, or fine netting be stretched over the opening, plenty of fresh air may be admitted without the disadvantage

resulting from wind, which is always unpleasant, and may be dangerous both to patients and attendants. Carpets should be taken up, and all curtains and hangings should be removed. The floor can be wiped over from time to time with a damp cloth which has been wrung out in dilute Condy's fluid.

I have often longed to try the effect of treating fever cases in tents or sheds, well closed at the back, sides, and roof, but open in front, with a thick curtain that could be drawn across in bad weather. Such apartments could be heated by hot water-pipes, and it would not be more difficult to protect the patients from draught than in a well ventilated room. I believe that such simply constructed open wards, built upon the flat roofs of our hospitals, would be found most advantageous for the treatment of a large class of medical diseases, as well as some surgical operations, while the chances of the disease spreading would be reduced to a minimum. The experiment might be tried very easily in the gardens of some of our county infirmaries, and I think many of our surgeons would place cases of operation in the same sort of open air sheds. I remember that the late Professor Günther, of Leipzig, treated many of his operations in this way and with the best results. The sheds he had erected were of the simplest possible construction, but they worked well for some years. The great difficulty in trying such an experiment in most London hospitals is the height of the building, but in the new St.

Thomas' Hospital, open air treatment might be tried very easily in the terraces at the ends of the wards, and without adding to the work of those engaged in nursing and supplying the diets.

Beds.—There is much to be said upon the subject of beds in connection with the treatment of cases of fever. If the bed is very hard the patient suffers much, but on the other hand, it may be too soft. A water bed is most unpleasant for patients, unless they are really quite helpless. Upon the whole, I think a good thick hair mattress, or two hair mattresses one over the other is to be preferred. By the aid of an eider down quilt, or the cheaper arctic goose down coverlet, the surface may be made quite even and pleasant to the patient without being too yielding.

The clothes covering the patient should be light but warm. There is nothing better than good blankets. For very delicate patients, eider down coverlets will be found advantageous.

In very severe cases extending over many weeks there will be danger of bed sores in spite of all our precautions. All prominent parts of the body should be examined by the medical attendant himself every second or third day. In most cases the position of the patient can be varied from time to time, and, with the aid of soft pillows, he may be kept for a time lying on one or other side without any muscular exertion upon his part. The patient's comfort is often increased by sponging the body daily, only a

small portion of the surface being exposed to the air at a time. Some Condy's fluid may be mixed with the warm or tepid water that is used. Rose water or camphor water, or water with a little eau-de-cologne mixed with it is preferred by some. Very dilute hydrochloric acid has been used, and water with one or two per cent. of carbolic acid may be employed when requisite. The skin on the prominent parts may be moistened from time to time by a little diluted spirit, and if the patient is very thin, it is a good plan to apply collodion and castor oil every second or third day, even though there is no threatening of a bed-sore. This application strengthens the cuticle, and I believe by its use we are often able entirely to prevent the occurrence of this painful and distressing complication.

APPENDIX.

Concerning Magnifying Powers.

In order that some idea may be formed of the degree of magnifying power of the *one-fiftieth of an inch object glass*, lately made for me by Messrs. Powell and Lealand, it may be stated, that if it were possible to see a human hair in its entire width under this power, it would appear to be nearly one foot in diameter, and an object an inch in height would be made to appear 250 feet high.

Dr. Lewis's Observations on Hallier's Cholera Fungus.

Since the first sheets of this work were printed, I have received from Calcutta, through the kindness of the author, a copy of the "Report on the Microscopic Objects found in Cholera Evacuations, &c.," by Assistant-Surgeon Lewis, M.B., attached to the Sanitary Commissioner with the Government of India. By a series of most careful microscopic investigations it is proved for once and for all, that Hallier's views on cholera are erroneous. His cholera fungus is not peculiar to cholera stools. Dr. Lewis's Report is illustrated by nearly a hundred very careful drawings, exhibiting points of great interest and importance. Every one studying the subject of disease germs should see this Report. Some of the questions referred to in the first part of my work are considered with great care, and several of the conclusions at which I have arrived receive support from Dr. Lewis's observations. To the correctness of his drawings, and remarks upon Bennett's and Pouchet's statements (p. 48 of Dr. Lewis's Report), I can bear testimony.

Bioplasm and the Contact Theory.

For a general statement of the nature of morbid poisons and the growth and changes occurring in bioplasm in

disease, the reader is referred to a little work by Dr. Morris, entitled "Germinal Matter, and the Contact Theory: an Essay on the Morbid Poisons, their nature, sources, effects, migrations, and the means of limiting their noxious agency." J. & A. CHURCHILL.

Dr. Bastian's Researches on Heterogenesis.

The experiments recorded by Dr. Bastian in 1870, and the reasonings advanced by him in a series of papers published in "Nature," have been recently examined and criticised. Several organisms have been described by Dr. Bastian which certainly ought not to have been found under the circumstances related by him. For instance, a piece of vegetable tissue which is probably a portion of bog moss, and penicillium in fructification, as well as some wormlike organisms have been figured. Few will be inclined to support the opinion that such bodies were actually formed in the closed vessels as maintained. Dr. Bastian brings forward many arguments in support of his experimental results, which are altogether superfluous if the experiments are to be relied upon. The experiments themselves have however been repeated with very great care by Mr. Hartley, who has altogether failed to confirm Dr. Bastian's conclusions. Mr. Hartley's paper is entitled "Experiments concerning the Evolution of Life from Lifeless Matter," and is published in vol. xx of the *Proceedings of the Royal Society*, December 7, 1871. I quite agree with the author in the views he has expressed, and gladly endorse his concluding remarks on the hypothesis of Heterogenesis. "The theory involves the discovery of a new property of matter, the property that certain compounds (undefined nitrogenous particles in the atmosphere) must have of decomposing molecules of other substances with which they are in contact, and building out of their constituent atoms substances of a much more complicated nature, without the exertion of external forces; even beyond this, they must be capable of arranging those compounds into definite forms. In the course of nature complex substances do not increase but simplify their molecular complexity. By oxidation vegetable products are resolved

into carbonic acid and water; we find no tendency in these oxides of carbon and hydrogen to become reduced to such products as sugar, starch or cellulose, nay, much further, we know no process by which such transformation might be effected, still less are we acquainted with any internal forces which can mould them into cells with functions to perform. *On this account a very great deal of thoroughly sound experimental evidence is necessary to establish the doctrine of evolution of life de novo.* But so far as our present knowledge guides us, whether we term it spontaneous generation, abiogenesis or archebiosis, the process by which living things spring from lifeless matter must be said to be only ideal."

Omitted on Page 280.

Injecting Carbolic Acid into the Diseased Animal's Blood.—It occurred to Mr. Crookes, that as he could so successfully attack and destroy the floating disease germs by atmospheric disinfectants, he might so be able to neutralize the virus in the blood by the introduction into it of appropriate antiseptics, especially as Dr. De Ricci, Professor Polli, Dr. McDowall, Dr. Waters and others had advantageously used in this way sulphites and bisulphites as prophylactics and cures in zymotic diseases. Injection of carbolic acid (4 per cent. solution) was tried on an animal having cattle plague; six ounces containing 105 grains of pure carbolic acid were injected, the animal appearing to suffer no inconvenience from it after the first trembling, consequent upon the disturbing influence upon the circulation had subsided. The cow gradually improved, and at length perfectly recovered. *See* p. 301.

A Lady six months Pregnant, recently Vaccinated, took Small Pox, and conferred an immunity upon her Child.

Dr. Calthrop published the following in the *Lancet* of September 23, 1871:—

Mr. F. had the eruption of small-pox developed on March 6th; the disease was of a mild kind, and he was soon convalescent. Mrs. F., six months pregnant at the

time, nursed her husband. On March 7th I revaccinated Mrs. F., she having two inferior marks of previous vaccination; she did not take. On March 11th I again revaccinated Mrs. F., when all three places took, and she had a very good arm. On March 21st, Mrs. F. took ill; small-pox eruption was developed on the 24th, there being fifteen or sixteen pustules. She was very ill for some days, premature labour being imminent; but she did well, and on June 27th was delivered of a healthy child, the said child having neither pit nor sign of the disease upon it. On July 20th, August 1st, and 16th, I vaccinated the infant, but each time unsuccessfully."

Case in which Small-Pox was not taken by Unvaccinated Persons.

For the following facts I am indebted to the Lady Superior of St. John's House.

"S. L., aged 13, Westminster, took the small-pox in March, 1871. The rash was fully out all over face and body March 10th. The mother and baby of a week old slept in the same bed and continued to do so. The baby has never been vaccinated, and is now nine weeks old, and has been sleeping in the bed night and day. The mother was vaccinated as a child, 35 years ago. The other children in the room had been vaccinated. The father has never been vaccinated at all, and slept in the same room. No other member of the family has had the small-pox."

Preparation of Vaccine Lymph in Glycerine.

The fresh vaccine lymph is placed in the hollow of a watch-glass, and there mixed with twice its quantity of Price's pure glycerine and as much distilled water. The liquids are thoroughly well incorporated with a paint-brush. The mixture may be preserved for use in capillary tubes or small medicine glasses. The lymph thus procured is considered equal in effect to pure lymph; care must, however, be taken to shake it before use, as the particles of vaccine bioplasm gradually subside to the lowest part of the fluid.

INDEX.

INDEX TO ILLUSTRATIONS.

THE END.

TO THE BINDER.

NOTE.—Plate XXII. to be inserted opposite to page 186 instead of 184, as directed at the foot of the Plate

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